PROCEEDINGS

OF THE

American Gas Institute

FIRST ANNUAL MEETING

October 17, 18, 19, 1906

CHICAGO, ILL.

PUBLISHED BY THE INSTITUTE

EDITED BY THE SECRETARY

1907

THE TRIBUNE COMPANY
NEW ALBANY, IND.

OFFICERS

OF THE

AMERICAN GAS INSTITUTE

First Annual Meeting

OCTOBER, 1906

COMPOSED OF THE PRESIDENTS, FIRST VICE PRESIDENTS AND SECRETARIES OF THE OHIO, AMERICAN AND WESTERN GAS ASSOCIATIONS.

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LIST OF SPEAKERS.

WITH SUBJECTS DISCUSSED.

REPORT OF THE PROCEEDINGS

OF THE

AMERICAN GAS INSTITUTE

FIRST ANNUAL MEETING

HELD AT

AUDITORIUM HOTEL, CHICAGO, ILLINOIS,

OCTOBER 17, 18, 19, 1906.

FIRST DAY—MORNING SESSION.

The Convention was called to order at 10 A. M., Wednesday, October 17th, in the Banqueting Hall of the Auditorium Hotel, Chicago, Ill., President B. W. Perkins in the chair.

The following gentlemen were present:

Africa, Walter G.	Manchester, N. H.
Allen, William H.	Newark, N. J.
Allison, Walter A.	Philadelphia, Pa.
Ames, Knowlton L.	Chicago, Ill.
Andrews, C. W.	Duluth, Minn.
Arthur, F. M.	Philadelphia, Pa.
Asendorf, Carl	Chicago, Ill.
Averill, Glenn M.	Cedar Rapids, Ia.
Azoy, A. C. M.	New York, N. Y.
Baehr, Wm. Alfred	St. Louis, Mo.
Baines, George B.	Admore, Pa.
Baldwin, C. K.	Chicago, Ill.
Baldwin, Wareham S.	Sedalia, Mo.
Barrett, Wm. E.	New York, N. Y.
Barnes, George W.	Pittsburg, Pa.

Barnes, Wm. W	New York, N. Y.
Barthold, W. H	Saginaw, Mich.
Battin, Henry S	Philadelphia, Pa.
Baxter, Isaac	Detroit, Mich.
Beadenkoff, Geo	Baltimore, Md.
Beal, T. R.	Poughkeepsie, N. Y.
Beal, Wm. R.	New York.
Bedard, F. W	LaSalle, Ill.
Behringer, E. V	New York City.
Bement, A.	Chicago.
Bennett, Charles W	Asbury Park, N. J.
Berger, E. T	Bloomington, Ill.
Bertrand, P. A.	Jefferson City, Mo.
Bigelow, A. F	Allentown, Pa.
Bigelow, Lucius G.	New York, N. Y.
Bingham, R. W.	LaSalle, Ill.
Blinks, Walter M.	Kalamazoo, Mich.
Bond, Charles O	Philadelphia, Pa.
Bottancott, Geo.	Baltimore, Md.
Bradley, C. W.	Oak Park, Ill.
Bradley, Wm. H.	New York.
Braine, Jno. H	Newark, N. J.
Briggs, G. W.	Westerly, R. I.
Brown, D. F	Albany, N. Y.
Brown, E. C	New York.
Brown, R. B	Milwaukee, Wis.
Brownell, E. E.	Chicago, Ill.
Buck, H. M.	Waukesha, Wis.
Bump, M. R	Denver, Colo.
Butterworth, C. W.	St. Albans, Vt.
Butterworth, Irwin	Detroit, Mich.
Butler, Mathew W.	Philadelphia, Pa.
Byers, C. A.	Toledo, Ohio.
Campbell, S. K.	Plainfield, N. J.
Cantrill, A. N.	Pueblo, Colo.
Carpenter, H. A.	Pittsburg, Pa.
Carnes, F. S.	Chicago, Ill.
Carson, Geo. S	Iowa City, Ia.
Cartwright, Henry R.	Philadelphia, Pa.

Castor, William A.	Frankford, Pa.
Cathels, Edmund	Providence, R. I.
Chessman, Frank P.	New York, N. Y.
Chichester, Alfred A.	Chicago, Ill.
Choate, Robert R.	Muskegon, Mich.
Chollar, B. E.	Kansas City, Mo.
Chrisholm, Chas. T.	Kalamazoo, Mich.
Chubb, Chester N.	Sioux Falls, S. D.
Clabaugh, G. W.	Omaha, Neb.
Clark, Jno. D. C.	St. Louis, Mo.
Clark, Walton	Philadelphia, Pa.
Clary, Edward D.	Burlington, Ia.
Clausen, Wm. F.	Bloomington, Ill.
Clifford, Thomas C.	Pittsburgh, Pa.
Cline, W. B.	Los Angeles, Cal.
Collins, Carroll	Marshall, Mich.
Collins, David J.	Philadelphia, Pa.
Combs, R. B.	Philadelphia, Pa.
Connors, Mathias	Chicago, Ill.
Coombs, Fred S.	Youngstown, Ohio.
Cooper, Wm. H.	Amsterdam, N. Y.
Corbus, F. G.	Philadelphia, Pa.
Cornish, R. C.	Milwaukee, Wis.
Cortis, D. T.	Boston, Mass.
Cowdery, Edward G.	St. Louis, Mo.
Crane, Wm. M.	New York.
Crawford, E	Sterling, Ill.
Crawford, Thomas	Clinton, Iowa.
Cressler, C. H.	Ft. Wayne, Ind.
Cressler, K. M.	Ft. Wayne, Ind.
Crighton, D. K.	Lansing, Mich.
Crowell, Fred B.	Atlanta, Ga.
Cruse, Arthur R.	Philadelphia, Pa.
Cunningham, Jno. H.	Westminster, Md.
Cunningham, T. J.	New York.
Curtis, S. P.	Philadelphia, Pa.
Dales, James Stuart, Jr.	Grand Rapids, Mich.
Daly, Augustin J.	St. Louis, Mo.
Davidson Edw. S.	Chicago, Ill.

Davidson, R. A.	New York, N. Y.
Day, C. L.	Chicago, Ill.
Dean, Mark	New York, N. Y.
Degener, Paul A.	Chicago, Ill.
DeHart, J. S.	Newark, N. J.
Dell, Jno.	St. Louis, Mo.
Denison, Harry	Ridgewood, N. J.
Dewey, V. F.	Detroit, Mich.
Dexter, MacDougald	Columbus, Ga.
Dickel, Carl A.	Philadelphia, Pa.
Dickey, Chas. H.	Baltimore, Md.
Dickey, Edmund I.	Baltimore, Md.
Dickerson, J. N.	Oswego, N. Y.
Dixon, J. Alfred	New York, N. Y.
Doelker, W. F	Mattoon, Ill.
Doherty, H. L.	New York.
Dolley, Geo. M	Peru, Ind.
Donahue, E. J	Jersey City, N. J.
Doty, Paul	St. Paul, Minn.
Douglas, Henry W.	Ann Arbor, Mich.
Dunbar, C. H.	Houston, Tex.
Dunbar, James W	New Albany, Ind.
Dutton, Lewis R	Wyncoke, Pa.
Earnshaw, Edward H	Cincinnati, Ohio.
Easton, Frederick W	Pawtucket, R. I.
Eaton, A. B.	Chicago, Ill.
Eaton, W. M	Rochester, N. Y.
Egner, Frederick	Norfolk, Va.
Elliott, Geo. H.	Chicago, Ill.
Elliott, H. J	Chicago, Ill.
Ellis, Jno. W	Providence, R. I.
Ellison, A. E	Cleveland, Ohio.
Engel, Francis	Elizabeth, N. J.
English, A. L.	Council Bluffs, Ia.
Eustace, J. H.	Chicago, Ill.
Everett, A. H.	Pittsburg, Pa.
Farr, Albert L	Chicago, Ill.
Feurtado, R. S.	Chicago, Ill.
Ferguson, B. B.	Portsmouth, Va.

Ferrier, James	Rome, Ga.
Fisher, Thos. J.	Washington, D. C.
Fitzgerald, Leonard	Palestine, Texas.
Forbes, Charles	Ottawa, Ont., Canada.
Forstall, Alfred E	New York, N. Y.
Forstall, Walton	Philadelphia, Pa.
Fowler, J. Scott	Philadelphia, Pa.
Frampton, R. C	Pittsburg, Pa.
Frazer, D. H.	Battle Creek, Mich.
Freeze, Fred. W.	Fort Wayne, Ind.
Frost, W. H.	Detroit, Mich.
Gaitley, John E.	Albany, N. Y.
Ganser, H. H.	Norristown, Pa.
Gardiner, Jr., W. H.	New York City.
Gartley, Wm. H.	Philadelphia, Pa.
George, Thos. L.	Philadelphia, Pa.
Gibson, Wm.	Hamilton, Ont., Can.
Gildersleeve, David H	New York, N. Y.
Gillette, F. A.	Waverly, N. Y.
Gillette, M.	Newark, Ohio.
Gilman, Geo. P	Chicago, Ill.
Ginley, John.	Chicago, Ill.
Glass, Sheldon J.	Milwaukee, Wis.
Goudy, W. R.	Sioux City, Iowa.
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Graf, Carl H.	Indianapolis, Ind.
Graham, L. C.	Winona, Minn.
Graves, George W.	Rochester, N. Y.
Gribbel, Jno.	Philadelphia, Pa.
Guffy, Jos. F.	Pittsburg, Pa.
Guldlin, O. N	Ft. Wayne, Ind.
Haines, J.	Des Moines, Ia.
Hamlink, L. C.	St. Louis, Mo.
Hammon, Wm. H	Pittsburg, Pa.
Hardick, Chas. F.	Philadelphia, Pa.
Harrington, A. S.	Chicago, Ill.
Harrop, H. B.	Milwaukee, Wis.
Harper, H. D.	Chicago, Ill.
Hart, Wm. F	Washington, D. C.

Hartman, Wm. E	Joliet, Ill.
Haase, Ewald	Milwaukee, Wis.
Hayward, Sterling F.	New York, N. Y.
Hicks, Jr., Geo. C.	Connorsville, Ind.
Hofman, Lothar	Fort Wayne, Ind.
Hoffman, J. G.	Detroit, Mich.
Holzer, Edwin G.	Easton, Pa.
Horton, Thos. O	New York.
Howard, Abram C.	Philadelphia, Pa.
Howard, J. B.	Galena, Ill.
Hoyt, Harry B.	Michigan City, Ind.
Humphreys, J. J. Jr.	Coney Island, N. Y.
Hunt, H. R.	Chicago, Ill.
Hutchinson, F. R	Camden, N. J.
Hyde, Henry H.	Racine, Wis.
Jacobs, Charles H	Detroit, Mich.
James, F. M	Aurora, Ill.
Jenks, R. J	Evanston, Ill.
Johnson, A. H.	Chicago, Ill.
Johnson, D. F.	Elkhart, Ind.
Johnston, E. D.	Connersville, Ind.
Johnston, Mervyn E	Newark, N. J.
Johnson, W. B.	Madison, Wis.
Jones, T. C	Delaware, Ohio.
Jourdan, James H	Brooklyn, N. Y.
Kahn, Julius.	New York, N. Y.
Keillor, John	Hamilton, Ont., Can.
Kelley, F. W	Davenport, Iowa.
Kellogg, L. L.	Sioux City, Iowa.
Kellum, Benjamin J	Chicago, Ill.
Kenan, Norman G.	Cincinnati, Ohio.
Keppleman, D. E	Santa Barbara, Cal.
Keppleman, Jno. H.	Reading, Pa.
Kerg, J. H.	Chicago, Ill.
Kersting, Albert F.	Mobile, Ala.
Kimball, Roger N	Kenosha, Wis.
Kincaid, H. E	Jackson, Tenn.
Kinze, Joseph H.	Chicago, Ill.
Kircher, H. P.	Belleville, Ill.

Knight, J. J	Kalamazoo, Mich.
Knowles, Wm. P.	Richmond, Ind.
Lapthorn, James	New Britain, Conn.
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Lathrop, F. H	Chicago, Ill.
Lawlor, R. W.	Waterloo, Iowa.
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Leakey, N. G	Detroit, Mich.
Leamy, Alan	Pittsburg, Pa.
Learned, Charles A.	Meriden, Conn.
Learned, Waldo A.	Newton, Mass.
Linde, F. C.	Chicago Heights, Ill.
Lindsay, Charles R	Chicago, Ill.
Linton, Samuel E., Jr.	Vicksburg, Miss.
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Lloyd, Earnest F.	Adrian, Mich.
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Long, H. J	Allegheny, Pa.
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Luther, F. E.	Chicago, Ill.
Lynn, James T.	Detroit, Mich.
Lyons, B. F.	Beloit, Wis.
MacBeth, George T.	Mt. Vernon, N. Y.
MacMillian, Robt.	Kansas City, Mo.
Mainland, Sinclair.	Oshkosh, Wis.
Mainland, Wm.	Oshkosh, Wis.
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Mallory, A. S	New York, N. Y.
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Mansur, John H.	Royersford, Pa.
Mayer, J. E.	Chicago, Ill.
Maxwell, Jos. Potts	New Brighton, N. Y.
McClary, N. A.	Chicago, Ill.
McDonald, Donald	Louisville, Ky.
McDonald, Donald	Albany, N. Y.
McDonald, Wm.	Albany, N. Y.

McDowell, J. C	Pittsburg, Pa.
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McGuire, Henry	St. Louis, Mo.
McIlhenny, Jno	Philadelphia, Pa.
McIlhenny, Jno. D	Philadelphia, Pa.
McIlravy, A. N	New York, N. Y.
McKay, Chas	Watertown, Wis.
McKay, W. E.	Milton, Mass.
McLaughlin, R. A.	Galesburg, Ill.
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Miller, Robert S.	Independence, Mo.
Miller, Thos. D	New Orleans, La.
Miller, W. A.	Cincinnati, Ohio.
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Pond, E. C . . . . Petersburg, Va.
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Pratt, E. G., Jr . . . . St. Paul, Minn.
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Printz, Charles H . . . . Fort Wayne, Ind.
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Putman, William R. . . . . Red Wing, Minn.
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Richards, Fred. M	Madison, Wis.
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Riddell, Herbert	New York.
Rieha, Edward L.	St. Louis, Mo.
Riseley, Wm. S.	Buffalo, N. Y.
Roberts, F. M	Mt. Vernon, N. Y.
Rodgers, Edward H	Philadelphia, Pa.
Rogers, W. H.	Paterson, N. J.
Roohan, Patrick F.	Saratoga Spgs., N. Y.
Roper, George D	Rockford, Ill.
Rugenberger, John M.	Philadelphia, Pa.
Runner, R. K.	DeKalb, Ill.
Runner, Z. T. F.	Freeport, Ill.
Rusby, John M.	Philadelphia, Pa.
Russell, D. R	St. Louis, Mo.
Salmon, Edw.	Beloit, Wis.
Sayer, E. Y.	Denver, Colo.
Schall, Henry D.	Oak Park, Ill.
Schiller, Chas. C.	Baltimore, Md.
Schmidt, F. W.	Jersey City, N. J.
Schutt, Henry L.	Buffalo, N. Y.
Searle, R. M.	Rochester, N. Y.
Secord, Warren L.	Ossinning, N. Y.
Shacklette, R.	Adrian, Mich.
Shattuck, John D.	Chester, Pa.
Shelton, F. H.	Philadelphia, Pa.
Shirra, J. C.	Milwaukee, Wis.
Sinsel, Otis A.	Detroit, Mich.
Slade, Richmond E.	Hartford, Conn.
Smart, F. R., Jr.	York, Pa.
Smith, Elmer W.	Kewanee, Ill.
Snow, W. H.	Holyoke, Mass.
Snyder, Charles S.	Philadelphia, Pa.
Spangenberg, B. H.	Philadelphia, Pa.
Speller, Frank N.	Pittsburg, Pa.

Spinning, W. V.	Peru, Ind.
Spragle, L. D.	Gloversville, N. Y.
Springer, E. S.	Leavenworth, Kas.
Stacey, Frederick A.	Chillicothe, Ohio.
Starr, H. W.	Schenectady, N. Y.
Steinwedell, Carl	Butte, Mont.
Steinwedell, George	St. Paul, Minn.
Steinwedell, William	Quincy, Ill.
Steinwedell, W. E.	Cleveland, Ohio.
Stone, F. W.	Ashtabula, Ohio.
Stratton, S. S.	Chicago, Ill.
Strohn, C. B.	Elgin, Ill.
Strohn, R. H.	Aurora, Ill.
Summers, George	Chicago, Ill.
Summers, T. W.	Ithaca, N. Y.
Summey, D. L.	Waterbury, Ct.
Sweetman, M. M.	Kansas City, Mo.
Sweetman, W. D.	Chicago, Ill.
Tait, Frank M.	Dayton, Ohio.
Talbott, Frank	Danville, Va.
Taussig, J. H.	Philadelphia, Pa.
Taylor, Jos. D	Richmond, Ind.
Thomson, George W.	Chester, Pa.
Thwing, O. O.	Ft. Wayne, Ind.
Tippey, B. O	Grand Rapids, Mich.
Tinsman, E. H.	St. Louis, Mo.
Tompkins, John P.	Atlantic City, N. J.
Traver, A. F.	Grand Rapids, Mich.
Travis, Frank M.	Torrington, Conn.
Tucker, C. A.	Rochester, N. Y.
Tutwilder, C. C.	Philadelphia, Pa.
Van Wie, Edwin G.	Detroit, Mich.
von Maur, J. D.	St. Louis, Mo.
Wagner, Fred H.	Baltimore, Md.
Wallace, William	Lafayette, Ind.
Walker, William L.	Fitchburg, Mass.
Walters, B. S.	South Bend, Ind.
Waring, George H.	Omaha, Neb.
Warmington, D. R.	Cleveland, Ohio.

Welch, William McNair	Independence, Kas.
Westcott, John T.	London, England.
Wharton, Henry	Philadelphia, Pa.
Whittaker, Allen D.	Patterson, N. J.
White, Henry H.	Wausau, Wis.
Whitfield, Albert	Chicago, Ill.
Wickham, Leigh	St. Louis, Mo.
Wilbraham, John S.	Philadelphia, Pa.
Williams, George	New York, N. Y.
Williams, H. G	Pottstown, Pa.
Williams, Luther S.	Harrisburg, Pa.
Williamson, John	Chicago, Ill.
Wilkinson, A. L.	Detroit, Mich.
Wilson, H. H.	Fort Madison, Iowa.
Wilson, William	Chicago, Ill.
Wishart, T.	Lafayette, Ind.
Witherby, E. E.	New York, N. Y.
Wood, Edward R.	Philadelphia, Pa.
Wood, Thomas B.	Berlin, Wis.
Woollen, Arthur L.	New York, N. Y.
Wones, W. R.	Covington, Ky.
Worthan, E. L.	Chicago, Ill.
Wright, E. J. H.	Oak Park, Ill.
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Zitzewitz, Herman	Chicago, Ill.
Zeek, C. F	Pensacola, Fla.

ADDRESS OF WELCOME.

THE PRESIDENT: Gentlemen, it is my pleasure this morning to introduce to you, Judge Dunne, Mayor of Chicago, who will give you a few words of welcome.

MAYOR DUNNE: Mr. Chairman and members of the American Gas Institute: It gives me pleasure, not only as a private citizen, but as the Executive of this great city of two millions of people, to welcome this very able and very representative body within the gates of the city. The city of Chicago is

anxious at all times to have conventions of this character, composed of men of representative character and standing, come to this city. We have always a welcome to extend to all classes of American citizens who are engaged in manufacturing work in some line for the public good. I am particularly pleased to welcome a body of this representative character, and composed of men who are engaged in the great gas manufacturing industry of the United States. You are here, I suppose, for the purpose of discussing among yourselves the latest methods, and latest appliances for the manufacture of that great public utility—gas. I presume it is natural, in a gathering of this kind, that there should be some air, whether it be hot or cold, injected into the gas question, as there usually is in our pipes. I regret that this convention did not meet in this city about six months ago, because I think I would have been able to corral about a dozen or so of the intelligent and well informed gas manufacturing engineers that are in this body, so that we might have availed ourselves here of the information and knowledge that they possess in connection with a certain ordinance which was pending before our City Council at that time. I had been informed by men in your line that the city of Chicago was able to obtain with fairness to the manufacturers of gas, and with fairness to the public, a rate of 75 cents, and I, therefore, recommended the passage of such an ordinance to the City Council. The City Council took considerable testimony on the subject, and I am sorry that they had not this body before them at that time to draw upon for information as to what ought to be the price of gas in the city of Chicago, but at any rate the City Council finally reached the conclusion that an eighty-five cent rate was reasonable and just. Judging from such information as I was able to get, I was led to veto that ordinance, for I felt that we in Chicago ought to be able to get gas as cheap as they get it in Cleveland or Duluth, and other similar cities, but the Council thought differently about it, and the Mayor was overruled, so that we now have 85 cent gas in this city as against 80 cents in New York, and as against 70 cents, I think, for gas in Cleveland.

Now, gentlemen, I hope that your deliberations will be

conducted with benefit, not only to your great and powerful organization, but with benefit to the community at large, and I trust that you will carry away with you a pleasant recollection of your visit.

We have some things in Chicago which may interest you besides gas. I think we have about as fine a lot of boulevards and parks as you will find in any place in the country. We are proud of our great city of two millions of people, and with its 26 miles of frontage upon the lake, which gives us the best and purest water in the world. We are proud of the city's progress, and of the great city that it is destined to become. I trust that while you are here you will avail yourselves of the time at your disposal, when not engaged in the deliberations of your body, and see our city. Unfortunately there is no fund with which to entertain such organizations as this. In fact, I believe it is against the law to appropriate money for that purpose, but I have no doubt you will find sufficient public spirit and sufficient generosity and hospitality to see that you are properly entertained while you are here.

Now again, gentlemen, let me say that I am sincerely pleased to welcome this body to this city, and trust that when you go away from it you will pleasantly remember your visit. I assure you that at all times you are heartily welcome in the city of Chicago. (Applause.)

THE PRESIDENT: I will ask Mr. C. H. Dickey to respond to the address of welcome.

RESPONSE.

MR. DICKEY: Mr. Mayor, it is with great pleasure that I extend the right hand of fellowship to you this morning in behalf of these gas men. We can readily understand why you should be so proud of the City of Chicago. The City of Chicago stands next to the greatest city in the United States, although I am told that there are a great many advantages in Chicago that do not prevail in other large cities. Here the streets are wider, and you have your great university, and many imposing buildings to lend beauty to this great western

town. And I can see very plainly, gentlemen, that his honor, the Mayor, must, with all his earnestness, have to work very hard at his job. Its no easy matter to run a municipality of this size, and keep all the wheels moving in unison, well greased, and in perfect working order. A man does not have to think a great while ahead before he understands it, and it is due to myself, his Honor, and to the people to say that the government has demonstrated how wisely your Honor is capable of doing it. I believe Chicago has been very well pleased in having .his Honor, Mayor Dunne, to represent it in the chair. And I feel with reference to the City of Chicago that what the Mayor says in regard to this wonderful water front, and with its railroad frontage, with its environment, and the immense tract of available land with which it is surrounded that no other city in the United States has a prospect of growth so indefinite, and some day we may wake up to find Chicago the largest city in population in the United States.

But your Honor, I want to call attention to these gentlemen who are sitting around you here today. It is seldom that you can go into any convention and see the intelligence that is depicted upon the countenances of these men. They are men who are also working at their jobs, and many of them have hard tasks, difficult tasks, and they have got to solve problems that you or nobody else outside of the gas business know anything about. The problems with which they have to deal are, many of them, exceedingly complex and difficult. They cannot tell at what time their holders may blow up, or leakages occur which may cause death in the communities. All these are accidents that may happen, and that do happen occasionally, no matter what means of prevention are taken, and there must be some means devised to take care of that stuff which is so apt to cause damage, and to prevent these things or bankruptcy stares us in the face.

The City of Chicago is fortunate in having one of the best equipped and up to date gas works in the United States, and I want to say here today to you that I congratulate the personel of this company because I know of the earnestness with which they go at their work, and the energy that they enthuse into every department in order to make it efficient so

that the citizens of this great city will be furnished with proper light and thoroughly satisfied with the product of the Peoples Gas Light & Coke Company.

Again, your Honor, I want to thank you for coming here and welcoming us to this great city, and to thank you on behalf of this Association, and I trust that these men, traveling as they do, and going over the United States from town to town, and some of them abroad, and meeting public men at all times and in all places seeking to ascertain what is known, and what is doing in this great industry,—these men I trust you will believe are trying earnestly and assiduously to produce for the best price possible a good product for their fellow citizens. Again I thank you for coming here, in behalf of these gentlemen, and extending to them, as you have, the hospitality of the City of Chicago. (Applause.)

THE PRESIDENT: I see by the program that the presiding officer is down for an address, but inasmuch as this is the initial meeting of the American Gas Institute the presiding officer will, no doubt, be expected to define its policy and all that sort of thing, but I do not feel capable of doing it, and if I did it would more probably result in debate which would uselessly take up your time, so I have decided to make no address. We will proceed with the order of business.

The next is the report of the Governing Board. We will listen, gentlemen, to the report of the Governing Board, which met for its session yesterday.

REPORT OF THE GOVERNING BOARD.

A meeting of the Governing Board of the American Gas Institute was called to order at the Auditorium Hotel, Chicago, Ill., Tuesday afternoon, October 16th, at 2 P. M., Mr. B. W. Perkins presiding.

The following members of the Board were present: Messrs. B. W. Perkins, K. M. Mitchell, C. F. Prichard, A. E. Forstall, Wm. A. Baehr, Geo. G. Ramsdell, T. C. Jones and James W. Dunbar.

Mr. Dunbar stated that a report had been received by the Merger Committee from Mr. John Williamson, Chairman of

the Committee on Arrangements, in regard to the result of the postal card vote in relation to holding a banquet, and that a majority of the members were against the proposition, and that, therefore, no action had been taken by that Committee. After full discussion, it was moved by Mr. A. E. Forstall that it is the sense of the Governing Board that a banquet be arranged for. To this motion an amendment was offered by Mr. K. M. Mitchell that the Institute dispense with the banquet this year in accordance with the expression ascertained by the postal card vote, and upon the matter being put to a vote the amendment was carried.

On the suggestion of the President, Mr. Dunbar read the report of the Committee appointed to obtain and submit plans and sketches for a badge for the Institute, and on motion of Mr. Mitchell, duly seconded and passed, it was voted that the badge recommended by the report of the Committee on Merger be adopted, and the committee continued.

Mr. Paul Doty appeared before the Board and read a report of the Committee on proposed sections for the American Gas Institute, and after discussion, on motion of Mr. K. M. Mitchell, duly seconded and passed, it was voted that the report on the report of the Committee on dividing the Institute into different classes of work be accepted and recommended to the association. The report of the Committee will be presented to you by Mr. Doty.

A communication was received by your Board from Mr. E. C. Brown, editor of Progressive Age, New York. in reference to the policy to be pursued by the board towards the gas light journals. On motion, duly seconded and passed, Mr. Brown's communication was received and ordered placed on file. On motion of Mr. A E. Forstall, seconded and passed, it was then voted that the report of the proceedings of this meeting, and until further action the reports of all meetings of the Institute be given to the gas journals, they to pay the extra expense of typewriting the extra copies, and with the understanding that they are either to publish such proceedings in full, as handed over to them by the Secretary, or, if they wish to

abridge, that they are not to publish the abridgement until it has been approved by the Secretary and author.

On motion of Mr. Forstall, duly seconded and passed, it was also voted that the publications of the American Gas Institute contain no advertising matter.

Mr. F. H. Shelton appeared before the Board and presented a statement showing the approximate liabilities and assets of the three associations joining in the merger to form the Institute as follows:

Cash, American Gas Light Association	$2,200.00
" Ohio Gas Association	200.00
" Western Gas Association	
Total cash	$2,400.00

Uncollected Dues.

American Gas Light Association	$ 496.00
Western Gas Association (approximately)	100.00
Ohio Gas Light Association (approximately)	200.00
Total	$ 796.00

In addition to the above the Institute will inherit some material from the three associations which has a more or less sale value in this respect: there are a lot of the proceedings of the American Gas Light Association covering many years. Some of them will undoubtedly be of value. In the Ohio Association there are 450 sets, and of the Western Gas Association 250 sets. The American Gas Light Association has a certain stock of the Uniform System of Accounting which was adopted by that Association, and also of the Electrolysis report.

The American Gas Light Association has about a dozen badges on hand, the Ohio about ten, and the Western about forty.

There is also The American Gas Light Association library, the George Treadway Thompson Memorial library, which is of value, and a certain amount of apparatus and models which is not of very great value.

The above is based on a discharge of sundry bills by all the

merger associations, deducting the necessary amount of cash to pay those bills, and each entering the merger free from debt. This excludes the Gas Educational Fund, which is entirely independent, and does not enter into the merger although conducted under The American Gas Light Association.

On motion of Mr. Mitchell it was voted that the report submitted by Mr. Shelton be received, and spread upon the records.

The report of Mr. James W. Dunbar as Treasurer of the American Gas Institute was submitted to the Board, and on motion, duly seconded and passed, was ordered referred to the Committee on Finance.

The question of what disposition should be made of the reports of the Secretaries of the three associations comprising the merger arose, and on motion of Mr. A. E. Forstall duly seconded and passed, it was voted, that in order to make the records of those associations complete the reports of the Secretaries be filed with the secretary of The American Gas Institute, and published with the proceedings of the first meeting of the Institute.

On motion of Mr. Ramsdell, duly seconded and passed, it was also voted that the proceedings of this meeting be published by the Secretary as soon after the close of the meeting as possible.

With reference to the papers collected to be read before the Association on motion, seconded and passed, it was voted that such papers as were reported by the Secretary as published and ready to be read, be approved.

On motion of Mr. A. E. Forstall, duly seconded and passed, it was voted the Board recommend to the Institute that the Institute complete the subscription to the Educational Fund previously made by The American Gas Light Association, and the Western Gas Light Association, respectively.

On motion of Mr. Dunbar it was recommended that members in good standing of the three Associations merged into the American Gas Institute, who have not petitioned for charter membership, be given thirty days to qualify as such.

On motion of Mr. K. M. Mitchell the Board voted that the

matter of selecting permanent headquarters be left to the Institute.

The Chair appointed Messrs. Geo. G. Ramsdell, T. C. Jones and James W. Dunbar as a membership committee.

The recommendation of the Committee on Merger that your Board recommend to the Institute that no honorary members be chosen for two years, and at no time until after the name of the candidate for honorary membership shall have been before the Board for at least one year, was adopted.

It was moved and seconded that the Board adjourn subject to the call of the Chairman. Carried.

JAMES W. DUNBAR,
Secretary.

MR. DUNBAR: With reference to the report of the Committee which was appointed on the classification of names I would say that the report from this committee embraces 881 names which have been published in this pamphlet, and the report of the Committee in reference to the members in the Ohio, Western, and American Gas Light Associations is as follows: "We, the Presidents and Secretaries of the American, Ohio, and Western Gas Associations, do certify to the correctness of the classifications of the applications received, and submitted herewith as respecting the respective associations, of which we are the officers."

CHARLES F. PRICHARD,
President, American Gas Association.
GEORGE G. RAMSDELL,
Secretary, American Gas Association.
B. W. PERKINS,
President, Ohio Gas Association.
T. C. JONES,
Secretary, Ohio Gas Association.
K. M. MITCHELL,
President, Western Gas Association.
JAMES W. DUNBAR,
Secretary, Western Gas Association.

MR. DUNBAR: This report includes favorable action on the 881 names which have been sent in by the members of the Ohio,

Western and American Associations to become charter members of the American Gas Institute. Some have been received since this supplemental list was reported. The report of the Committee includes those names also. And I will state that as the report indicates, thirty days will be given for any who may have failed to file their applications, or any who may have failed to be reported, to send in their applications to become charter members of the American Gas Institute.

THE PRESIDENT: Gentlemen, this report is before you. What is your pleasure?

MR. ALTON S. MILLER: I move that it be received, and that the recommendations be taken up in detail.

Motion seconded.

THE PRESIDENT: It is moved and seconded that this report be taken up, the recommendations taken up in detail. Are there any remarks? All in favor of the motion as stated will say "aye." Contrary minds "no." It is passed.

SECRETARY DUNBAR: The first paragraph is in reference to the banquet. The Governing Board recommends that in accordance with the postal card vote received that this year we have no banquet. Do you wish me to read the entire paragraph or merely give the substance?

THE PRESIDENT: No. The substance is enough.

MR. SHELTON: Mr. President, may I say a few words on that subject? I have received a good many comments, opinions and criticisms in connection with the banquet, or its absence, which has come to be as we all know, and has been for years one of the characteristic features of many of these meetings. The Institute in starting out through the Committee appointed to make arrangements for the meeting resolved that it would not be the beneficiary of our trade friends; that it would not come to this City of Chicago again and ask our good friends here to pay considerable sums to entertain us, and that if we had a banquet we would pay our individual proportion. It was certainly, to my mind, the right ground to take. And, so, on behalf of the Committee of the Institute it was decided to take a vote of the membership as

to whether each individual cared to pay the necessary sum for the entertainment, to consist mostly of the banquet. As the Secretary has pointed out the vote developed an apparent majority against the banquet, and accordingly, the Committee on Arrangements, perhaps preferring to play safe, decided that we would not have a formal banquet on this occasion, and that decision, in a sense, was ratified by the Governing Board yesterday. But there are two views, or two ways of looking at that vote which was taken. There were 209 replies against the banquet or not so much that, perhaps, as it was that there were 209 individuals who did not care to pay the necessary $10.00, but there were, on the other hand, almost an approximately equal number of gentlemen who did say that they wished a banquet, and would pay the necessary $10.00 for such a purpose. Now it has been thought hardly fair that those gentlemen who come here wishing to have the pleasure of dining together should be debarred from that because an approximately equal number did not care for it.

In addition to that situation there were some complications which arose locally, and which the Committee on Arrangements encountered despite good work on their part, and with the result, as I have said, that it has been decided that there would be no "official banquet," but there has been a movement among a number of gentlemen who feel that there is nothing in the world to hinder having a dinner of gas men informally, and without some of the frills that sometimes characterize banquets, and, in brief, it has been felt wise to after all refer the question back to you gentlemen on the floor to decide. There is still time to arrange for an informal "subscription dinner," if we choose to so call it, tomorrow night in this hotel, provided a sufficient number care to do it. There is nothing in the world to hinder any of us who would like to participate from getting together and bowing the old associations out and welcoming in the new, and having a time of good fellowship, and a good dinner. It will cost $10.00 to one willing to pay it, and to one not caring to pay it, there is nothing in the world about it that is obligatory at all. However, the matter, has been thrown squarely before you all. You are all here, and it rests with you gentlemen to say

whether you care to meet together tomorrow night, but on a basis that will cost $10.00, because it is proposed to have a pretty comfortable, satisfactory sort of dinner. If fifty or seventy-five or a hundred of you are certain in your minds that you would like to participate in such a way, or if some such number indicate that they would like to participate in a dinner, that will be enough to warrant the making of certain arrangements which will have to be made soon, and all you will have to do is to pledge yourselves to sign the subscription paper and pay your $10.00 afterwards. There seems to be no other way to do but to throw it back to you to decide whether we shall have a gas man's dinner together, to bury the old Association and start the new, and I am going to ask you, therefore, who enjoy that feature of our meetings if you will kindly hold up your hands. Those who vote in the affirmative kindly hold up their hand. Will the Secretary please make a count?

SECRETARY DUNBAR: 71.

MR. SHELTON: That number is sufficient to warrant making the arrangements. I think there will probably be a good many more come in before we get through. I do not believe there is any need of taking the negative vote, particularly because it is not a question, really, before the Institute to decide, but its simply a question of seeing if there are enough of those who care to have the dinner to warrant directing the hotel to make the necessary arrangements.

SECRETARY DUNBAR: The next paragraph is in reference to adopting the badge recommended by the Committee, which is the one you see here in the designs on the wall back of me. (Mr. Dunbar refers to colored designs upon the wall.)

THE PRESIDENT: We will hear the report of Mr. Shelton for the Badge Committee.

MR. SHELTON: The selection of the badge is not the most important thing in the world, for the Institute will do very good work for the gas industry if it never should have one, but it seems appropriate that the Institute should have a suitable badge for such convenience or pleasure as it may

offer or give, and a Committee on Badge, consisting of Mr. William McDonald and myself, was appointed. In considering the matter our main thought was that an appropriate badge, if possible, should be one that would incorporate a characteristic feature of each of the merging association badges, so that in a sense the new badge would be a charter badge, so that no matter what other associations may come in the future, and possibly ultimately merge or combine with the Institute, they would not be able to disturb the charter position of the three associations that already form this institute by a merger, as that would be perpetuated, in a sense, in the design of the badge. We; therefore, endeavored to incorporate features from the Ohio badge, the American badge, and from the Western Association badge. In addition, it was thought that a change in color might tend to differentiate a little from the red and blue heretofore mostly used, and it was suggested that we make it a green and gold badge this time. It was also felt that, artistically speaking—and this was said by people outside of the gas business—that the American badge was the best design of any of the existing badges, so that the committee aimed to adhere somewhat to the general effect of the American badge, and yet to specifically incorporate some of these certain other features, as stated. The result is before you in two designs. Number One includes the holder of the Ohio, the setting sun and pipes of the Western, and the torch of the American. The criticism that has been made of the design was that there was a little too much endeavor to get too much into a small space. The opinion finally prevailed that this badge, Number Two, was the stronger pattern, that the torch was a little bit larger, and that the setting sun was in evidence. And the Ohio men said that inasmuch as their O encircled the whole they were satisfied! At any rate, it is the choice of the Committee on Badge. It has been suggested, however, that the circle alone tends towards a button effect, and that the "ear" at the bottom of the American badge be added.

This is the formal report, which was prepared and handed to the Committee on Merger:

To the Governing Board American Gas Institute:

GENTLEMEN: The undersigned were appointed a committee to make recommendation in the matter of suitable badge for the American Gas Institute. We have received designs and prices from several makers, and submit the accompanying design as our choice. It is our recommendation that if your Board and the Institute accept this choice, that final bids be procured, and that the badge be made up of number 14 karat gold, with a 10 karat safety-lock pin, similar to the same device on the pin that the recent American Gas Light Association used. Further, that an additional price be named for engraving the initials or name of the owner, when desired, and finally that—*other things being equal*—the business be continued with the maker who has for many years supplied the American Gas Light Association.

We further recommend that badges for members at large, of all classes, be made up with green enamel; that the badge of the President be made up with white enamel; and the badge of the Vice-Presidents with blue enamel; and of the Secretary with red enamel. That the Institute be authorized to contract for one thousand as the price basis, to be delivered in suitable lots on call, and to be paid for as delivered, and that the charge to members be cost, plus twenty-five cents for postage, registration and recording, and that all badges be put under the following rules, which are to be printed and incorporated in the published notices of the Institute.

1. The badge of the American Gas Institute, adopted October 17th, 1906, shall consist of the design as above.

2. Each badge shall be numbered and registered with the name of the owner in the records of the Secretary.

3. The price of each badge shall be $3.75, which is to include forwarding charges by the Secretary to the recipient. A further charge of ——— cents shall be made if the recipient requests his name engraved on the back thereof.

4. It shall be expressly understood that if a member resigns or is dropped from the Institute, he shall return his badge and receive therefor the sum of $2.00.

Respectfully submitted,

WILLIAM MCDONALD,
F. H. SHELTON.

THE PRESIDENT: Now gentlemen, the recommendation of the Committee is before you. It is approved by the Governing Board, and it is now before you to accept or reject.

MR. SHELTON: If you like it approve it. If you dislike it vote it down and appoint another committee.

MR. PRATT: I move that the report of the Committee on Badge be adopted.

Motion seconded.

MR. DONALD MCDONALD, Louisville: Well, is this, Mr. President, just what we want? I move to amend that by substituting this other sketch. I think the badge of the Institute ought to say what it is. I do not see as the setting sun is in accordance with the principles of the business. If you have a badge with a gas holder on it why everybody knows at once, as soon as they see it, that it is in some way connected with the gas business. It seems to me that this other badge is the most appropriate and I move to amend Mr. Pratt's motion by adopting the report of the committee but substituting this first badge instead of the other one.

THE PRESIDENT: I would say, gentlemen, that one reason why this badge was chosen was this: they had exact sketches made of the two badges, and the detail was too great in this one to make it effective. That was one thing which influenced the choice of the committee.

MR. D. MCDONALD: But it does not seem to me, Mr. President, that the other one has anything about it which shows in particular that its a gas man's badge.

MR. MCILHENNY: It has the three pipes on it.

MR. NORRIS: I was about to say that it shows the rising sun, and the Institute is a rising sun.

MR. EGNER: Mr. President, instead of the letters, A.G.I. or instead of putting on those initials or letters I do not see why we could not put on "American Gas Institute," and then everybody would know at one that it was a badge destinctive of a gas association. I would suggest, or move, that instead of putting on just the letters we put on the name, American Gas Institute.

Mr. Roper: As I started to suggest a minute ago, Mr. President, I think we ought to change those letters. A man looking at that as it stands would be apt to think it was a G.A.R. badge. That is pretty common you know. A man looks at it, and he says "that's a G.A.R. man." I lost an arm in it and on account of that I am little sensitive on that point. I have been asked that question too many times. I think it would be a good idea to put on the name.

Mr. Donahue: I would move as an amendment that the pipe be removed from the circle, and that the name "American Gas Institute" be added. That the name be added by spelling it out in full.

Amendment seconded.

The President: It is moved and seconded as an amendment to the original motion that the pipe be left out of the circle, and that the name, American Gas Institute, be put on in full. It is open for discussion, gentlemen.

All in favor of the amendment will please say "aye." Contrary minds "no." I cannot decide it without your vote, gentlemen. All in favor of the amendment will stand up. The amendment is carried. I will now put the original motion as amended, that the report of the committee be accepted as amended. All in favor of the motion say "aye." Contrary minds "no." It is carried.

Secretary Dunbar: The next section is in reference to furnishing the proceedings in full to the various gas journals, they to publish them in full, paying for the additional copies, such expense as is incurred for typewriting, and with the understanding that such proceedings must be published in full as handed over to them by the Secretary, and if they wish to abridge that they are not to be permitted to publish the abridgement until it has been approved by the Secretary.

Mr. Ramsdell: I move its adoption.

Motion seconded.

The President: It is moved and seconded that that portion of the report be adopted. Any remarks?

Mr. Egner: Mr. President, I noticed after the last meet- of the Western Gas Association a report of our proceedings

published in one of the journals which was very much garbled. In fact, you would hardly know it. Whereas, in another of the journals it was quite full. Now I do not believe in discriminating one against the other, or anything of that kind, but I do believe it would be for the benefit of the American Gas Institute to have an official organ. I assure you, gentlemen, I have not been asked to say these words. It is entirely of my own free will and accord that I make these remarks, but I have noticed that the most successful gas associations are those which have an official organ. There is one which I believe is the most successful of all gas associations, namely, the German Association of Gas & Water Business Men, who have an official organ,—"The German Journal fuer Gasbelenchtung." Now if the other journals wish to publish the gas news or the proceedings I believe that they should have the right to do so, and should be furnished with the information, and with the proceedings if that is thought best, in some such a way as is recommended here. But I do believe, gentlemen, that we ought to have an official organ, and if it is in order I would like to make a motion that The American Gas Light Journal be made the official organ of the American Gas Institute.

We have, of course, grown very much. We have grown to be a large and strong body, but I do like to stand by an old friend, and I think it would be very proper, and it would help the Institute if that should be done. When the gas business was very weak, and our gas associations were few and small in numbers, the American Gas Light Journal used to send a reporter to take our proceedings, and they published our proceedings, and paid for them all by themselves. I can very well remember that, as can many of the men who are old now, and it was a great help to gas industry at that time to have that information given out in the published proceedings when the business was young in this country. If it is in order, Mr. President, I would like to make a motion that the American Gas Light Journal shall be the official organ of this Institute.

THE PRESIDENT: I would like to suggest, Mr. Egner, that you defer that until this other matter comes up. There is another matter before us now.

Mr. Doherty: Mr. President, if I may, I want to interject one suggestion right here, and that is that if the papers are to be published by the gas journals, or they are to be extracted, or there are to be digests published of them, they ought to be submitted to the authors before they are so published. The journals, instead of being allowed to publish such as they think proper of the papers or proceedings, and without caring anything for the opinions or wishes of the authors, I think should be put under some proper restriction in regard to this matter, so that the authors shall have something to say about it. I would not want a paper of mine to be published in extract without having an opportunity to revise it, and I hope that that will be required.

Now, in regard to the official organ, I do not believe in the Association having an official organ at all.

The President: Do you make that as a motion, Mr. Doherty, or will you put it in the form of a motion?

Mr. Doherty: Yes, I will make it as a motion, Mr. President, that the extracts from the papers shall only be printed with the consent of the author of the paper. That should be as an amendment rather.

The President: You make that as an amendment to the motion to adopt the recommendation of the Board?

Mr. Donald McDonald: Mr. President, I rise to a point of order; that the question of an official organ is not before us, and ought not to be considered.

The President: That is not being considered, Mr. McDonald.

Gentlemen, it has been moved, seconded and discussed, that the report be accepted as reported by the Board of Control, and as amended by Mr. Doherty, that no abridgement shall be made in the papers, if they are published by the gas journals, without the consent of the authors. All in favor of the motion will state it by saying "Aye." Contrary minds, "No." The motion is carried.

Secretary Dunbar: The next section is in reference to advertising in the publications of the American Gas Institute;

that the American Gas Institute, in the publication of its proceedings, shall solicit no advertising matter.

THE PRESIDENT: What is your pleasure, gentlemen, in regard to that?

MR. RAMSDELL: Move it be adopted.

MR. DOHERTY: Do I understand now, Mr. President, that the question is under that motion that the Institute would be prohibited from soliciting advertisements?

SECRETARY DUNBAR: That no advertising matter be contained in the publication of the proceedings of the Institute.

MR. DOHERTY: I would like to suggest that that matter, perhaps, deserves some serious thought before we take that action. Many of the members of this Institute probably fail to realize the vast cost of some of the publications that have been brought out by some of the individual associations. I know of one or two publications that have cost to exceed $3,000. The entire revenue of this Institute will not be to exceed $8,000. How is it going to publish anything of a very ambitious character without securing outside aid of some sort I do not know. You certainly cannot do it on that amount of money. This is done, I presume, for the protection of the gas light journals. I am as anxious as anybody else to protect the gas light journals, but I do not want to see the work of the Institute crippled in value, or lessened, simply to protect those journals. There is no man here more friendly to them than I am. Awhile ago I observed that one official notice of one department was paid for when it was inserted in one of the gas light journals. The department paid for the notice to help out the work. And I want also to make the suggestion, Mr. President, that advertisements have been secured for some publications that I know of that the gas journals cannot secure and do not secure. There is no reason why we should be excluded from securing the benefit of some of that revenue simply to protect the gas journals if it does not protect them. I do not believe that the gas journals will be hurt in the least by the insertion of advertising matter in the publications of the Institute, but whether they are or not, the Institute work

must go forward. There is no question of sentiment about it. That work must go forward, and I cannot see where we are going to get the revenue from any other direction to carry that work on if this source is cut off.

Mr. A. E. Forstall: As the mover of that resolution in the Governing Board I wish to say that, as I think that the most of the members of the Institute will understand, I did not make that motion for the sake of protecting the gas light journals. I am not in the habit of going around protecting the gas journals. I have other things to do. I made that motion for the sake of the dignity of the Institute. I have always felt that it was beneath the dignity of any association of this kind to publish anything that it could not pay for out of its own funds, and for the sake of publishing such things to go about soliciting advertisements. I dislike particularly to see a book come to me claiming to be issued by an association but which is paid for by advertising. I made that motion in order that the Institute should not be put in that position. It is not a question of protecting the gas journals at all. The gas journals can look out for themselves. It is a question of protecting the dignity of the Institute.

The President: There is no motion before the House. If some one will make a motion we can discuss this in order.

Mr. Doherty: I move that that section of the report of the Governing Board be rejected. I would like to have the reports issued by this Institute amount to something, and I do not think that we should shut ourselves off from this source of revenue if it should be needed. And I would like to say to Mr. Forstall that I had no wish to make it appear that there is any particular love for the gas journals. I think as he does, that they can take care of themselves, but I cannot see any reason for this unless it is a move for the protection of the journals. It is all very well to preserve the dignity of the Institute. You have got a very dignified organization, but I really believe that what we want is results, good practical results, and we cannot get them, or get what we should get, on our present income. I cannot see any possible use in our cutting off our income. If we do that, where are we going

to get our income from? If this motion is accepted, then I think those who vote for its acceptance should tell us where we are to get this necessary additional income from.

Mr. Bigelow: Mr. President, I do not wish to be understood as opposing this motion. However, I do not think that any gas journal in the field would object in the least to advertising matter appearing in the publications of the Institute if it is going to be a help. We do not need that kind of protection.

Mr. D. McDonald, Louisville: Mr. President, I do not think it is beneath the dignity of the Association to accept advertisements as long as we give value received. An advertisement of a gas appliance inserted with the report of this Institute should meet the eye of every man it is intended for, and so long as we do not do it as beggars, asking for something and giving nothing in return, we lose no dignity whatever. I believe that the advertising which will accompany these reports will be so valuable that it will not be necessary at all to solicit advertisements. For that reason I disagree with the position of my friend Forstall, that it is in any way beneath the dignity of the Institute to accept what we will be giving good value for in in return. I second Mr. Doherty's motion.

Mr. Shelton: If some that are here felt that they could speak their real feelings on this matter of advertising, not in regard to a really good proposition, but in connection with appeals for advertisements which we all know are made, I think the subject would present itself somewhat clearer here. But we do not dare to say what we hear outside. In my opinion, the Institute will have enough income from its legitimate and proper channels, and it had better do without that additional income than to get it by holding up our friends in the trade.

Mr. A. E. Forstall: I believe Mr. Doherty's motion was not seconded. I will therefore move, Mr. President, that the report be adopted.

A Member: I will second it.

The President: I understand that Mr. Doherty's motion was seconded.

Mr. Cunningham: Mr. President, I only wish to say to the gentlemen that with regard to the Gas Light Journal, it does not require protection, but it asks your co-operation.

Mr. Doherty: Mr. President, I do not like to talk merely for the sake of talking on any subject, but I am interested in this matter, and enough so in a way to strongly desire to see the work of the Institute go forward successfully. I know something of how these things work out. In days gone past I have been behind a number of enterprises in association work, especially where publications in which I have been interested were concerned, and I have gone down in my pocket and furnished the means in some cases that those publications required, and the money we received from advertising was always a valuable aid which came to us from many manufacturers. I know there has been lots of efforts sometimes to bring in advertisements, but I know of no man who felt that nothing would come of such advertising but what felt at perfect liberty to refuse, and in fact I think there is many a man who sits here in this room today who probably refused, but, on the other hand, there were a great many people who took the opportunity to advertise, and who came around and wanted it themselves. We can talk about the dignity of the Institute all we want to. I believe that one of the most dignified and one of the most useful bodies in the entire country is the American Institute of Electrical Engineers, but if you will look at any of their publications you will find that they contain much advertising matter. It is also the same with the National Electric Light Association, an association that we can very well study and learn something from their methods. That association accepts advertising. It is simply a question of whether the man who wants to benefit himself by putting an advertisement in your proceedings shall be allowed to do so. These books or pamphlets that will be published by the Society will be read by the gas men of the entire country, and will be valuable advertising mediums. If the matter is handled in that way, in my judgment it will enable the Institute to have more funds, and to do better and more efficient work.

Dr. Harrop: Mr. President, I do not always agree with Mr. Doherty, but in this matter I do most heartily agree with him. There are two pamphlets in circulation here today that I have had to with. One is the report of the Board of Revision, relating to the section, Distribution of Gas. That was published so as to bring a part of the Revision before the Institute, and was published at the expense of Mr. Stone and myself. There is no advertising in it. The other one is a reprint of my papers of gas works chemistry. That is printed at the expense of the Wisconsin Gas Association; it contains no advertising, but is held for sale. The pamphlet showing the report of the Board of Revision is free to the members of the Institute. Now it is, of course, a considerable burden to bring out a thing of this kind entirely at individual expense, but the amount of such matter that can be brought out by the Institute is limited only by the amount of its income. It is largely a question of expense, and I think it should be remembered that the advertising that goes into certain of these publications is worth a great deal of money to the advertisers. As Mr. Doherty has said, there are some advertisers who want the space, and who think it valuable, and who have felt that they could not afford to be without it. Some advertisements have been solicited, it is true; but I doubt if an advertising contribution has ever been demanded. I believe that the Institute can solicit advertising without degrading its dignity in the least. It can offer the opportunity of advertising in some of its publications even if it does nothing more. It need not ask any man, or plead with any man, or put it in a way that it will have the effect of demanding of any man any advertising; but it can at least give him the opportunity, and without the least sacrifice, as it seems to me, of its dignity in any respect. I would, therefore, make a motion to amend the motion before the house to read that the Institute shall be allowed to solicit advertising for such of its publications as it thinks fit through the Secretary, and through the Secretary only, and that the advertising be solicited only for such publications as the Secretary, or officers of the Institute, or the controlling board shall see fit.

Amendment seconded.

Mr. Roper: I would like to say, from the standpoint of one of the "abused," that this reminds me a good deal of a story that happened to me a few years ago. If you are going to run it on the dignity plan, or the dignity principle, it will be a good deal as it was with this gas company that I am going to speak of. I went to one man to sell him some gas stoves a few years ago. He was connected with a company located in one of our large New England cities, and after I had suggested, or told him what was being done in the West and other places, and what a help the gas stove was in soliciting the sale of gas, he leaned back in his chair and he says, "I hope the day will never come when we are obliged to ask anybody to burn gas." Soon after that that concern was selling out, and under a new manager they were selling about four times as much gas without the dignity as they were with it.

Mr. Gardiner: Mr. President, I would like to add a word of confirmation of the opinion expressed by Mr. Doherty, or in the amendment put forward by Mr. Doherty. I happen to be the Chairman of the Committee on Dues of the National Electric Light Association, and in that association we have considerable income, or a very large item of the income is derived from advertising in the proceedings. I have never heard one word of criticism as to its effect upon the dignity of the National Electric Light Association because it accepted advertising for its proceedings. That advertising revenue is a very large part, or a very large item of its income. I think that this American Gas Institute has a very large problem on its hands to do the work it seems to me it should with the present income at its command. I think that every source of income that can properly be availed of should be so availed of in order that we may do this work, and be a thoroughly effective association, and one that will stand.

Mr. E. C. Brown: Mr. President, it seems to me proper that I should state my views on this matter. Gentlemen who talk as Mr. Gardiner and others have here have not had an experience of twenty years in running a gas paper, and when he speaks of the advertising to be had in the electrical field I want say, Mr. President, that there is no comparison between

them at all. The gas industry is not to be compared with the electrical industry. It is true, as Mr. Doherty says, that the electrical publications have contained a good deal of advertising, but the general income derived from advertising in the electrical field is at least ten times what it is in the gas field. The amount of advertising to be obtained in the gas field is comparatively narrow. There are only about eleven hundred gas companies in this country, and of that number fully three hundred of the larger and more prominent companies are controlled by syndicates, and many of them are served by one purchasing agency. That narrows the field very materially, and, gentlemen, I am opposed, as I said before your Committee, to the soliciting of advertising by the American Gas Institute for its publication for that reason.

Mr. Norris: Mr. President, there seems to be two objections to the advertising, one that it is undignified, and the other that it is a hold-up on trade interests. So far as the dignity part is concerned, I do not give a hang for such an argument—that it is undignified. There is nothing, to my mind, undignified in the association having advertising matter in its publications. In regard to the hold-up, I do not see where the hold-up comes in. I do not see where there is any penalty attached to a refusal by anybody in regard to advertising in such publications. I am heartily in favor of allowing the Institute to issue advertisements, if it is so desired.

Mr. D. McDonald, Louisville: Mr. President, I just want to call attention to the fact that Mr. Doherty's motion is not to the effect that we shall go into the business of soliciting advertising, but, as I understand it, the effect of his motion would be to simply keep off from our records any prohibition that we shall not do so. If we pass his motion it does not necessarily mean that the Institute is to go into the business of soliciting advertising. Mr. Doherty's motion is merely that that section of the report be dropped, and the effect of it will be to leave the matter where it is.

The President: The motion was amended, Mr. McDonald.

Mr. D. McDonald, Louisville: There was an amendment offered but I did not understand that he accepted the amendment.

Mr. Doherty: I think, Mr. President, that there was a motion made that the report be accepted, and I amended it by asking for its rejection.

The President: It was also amended by Mr. Harrop to that same effect.

Dr. Harrop: I will withdraw that, Mr. President.

The President: That that portion of the report relating to advertising be rejected?

Dr. Harrop: No. If Mr. Doherty's motion prevails, it will simply reject the report, and, as I understand it, advertising can then still be solicited if it is found desirable.

The President: Then the motion is on the rejection of that portion of the report. All those in favor of the rejection of that part of the report which prohibits the Association from receiving advertising for its publication will say "Aye." Contrary minds, "No." The motion is carried.

Secretary Dunbar: The next paragraph, gentlemen, is in relation to the assets of the American Gas Institute. I suppose that is not a matter for consideration.

The next thing for consideration is the motion which was made by Mr. Ramsdell, that the proceedings of this meeting be published by the Secretary as soon after the close of the meeting as possible.

Mr. J. D. McIlhenny: Mr. President, I move its adoption.

Motion seconded.

The President: It is moved and seconded, gentlemen, that that clause of the report which calls for the publication of the proceedings of this meeting as soon as possible after we adjourn be adopted. All those in favor will say "Aye." Contrary minds, "No." It is carried.

Secretary Dunbar: The next paragraph is with reference to the adoption of the papers reported by the Secretary to be read to this association.

Mr. Ramsdell: I move its adoption.

Motion seconded.

THE PRESIDENT: All those in favor of the motion will signify by saying "Aye." Contrary minds. It is carried.

SECRETARY DUNBAR: The American Gas Light Association and the Western Gas Light Association have been contributors to the Gas Educational Fund. I think that the American Association contributed $250 and the Western Gas Light Association $100. The Board of Control recommends that the American Gas Institute contribute each year the total of the subscription of the American Gas Light Association and the Western Gas Association to the Gas Educational Fund.

MR. RAMSDELL: That is not quite right, I think, Mr. Secretary. I think the understanding was to continue the subscription until the term has expired. I move that that be done, Mr. President.

Motion seconded.

THE PRESIDENT: Gentlemen, you hear the motion. It is moved and seconded that that be done. All in favor of the motion will signify by saying "Aye." Contrary minds by the same sign. It is carried.

SECRETARY DUNBAR: The Board leaves the matter of the selection of the permanent headquarters of the Institute to the members present.

MR. DOHERTY: Mr. President, I would move that that be left in the hands of the incoming officers, that the selection of headquarters be left to the incoming officers.

A MEMBER: Mr. President, may I ask what that means? Does that mean permanent headquarters?

MR. DOHERTY: Yes, permanent headquarters.

MR. D. MCDONALD, Louisville: Does that mean, Mr. President, that if the Institute passes this motion that it gives the incoming officers power to select headquarters?

THE PRESIDENT: I presume that is the intention, Mr. McDonald. It is moved and seconded that the matter of selecting a permanent headquarters be referred to the incoming officers with power to act.

MR. D. MCDONALD, Louisville: Mr. President, I would

move to amend that to the effect that before final arrangements are made they shall report back to the Institute.

A MEMBER: May I ask, Mr. President, what the meaning of that term, "permanent headquarters," is?

THE PRESIDENT: It is proposed to have the Secretary, I believe, have a permanent place in Chicago, Cleveland, or wherever he may be, where the libraries, apparatus, and things of that sort may be kept, and from which the business of the Institute is to be conducted.

MR. NORCROSS: What is the purpose of that, Mr. Chairman? What has the Institute got which will require the establishment of such a place?

MR. A. E. FORSTALL: Mr. President, I may be able to answer Mr. Norcross's question. The Institute, as the effect of the merger, comes into possession of quite a mass of material, including copies of proceedings, libraries and more or less apparatus which has been donated at various times, and it is absolutely necessary that that should be kept in some permanent place, and not kept moving around the country. Therefore, it is very desirable and advisable that the Institute decide upon some permanent headquarters which would, at least, continue to be the headquarters for a period of years, or until some occasion arises making it necessary to change them, or making it worth while to change. Unless you do that, we may change the headquarters every year. The Secretary is elected every year, and unless something of that kind is done we may change the headquarters of the Institute with the changing of the secretaries from year to year. If we cannot get anybody to take the job, and it was left as it is at present, the things would have to be shifted around the country with each change in the secretary, and in a short time the things would be destroyed or be used up by freight charges.

MR. MITCHELL: Mr. President, I move as an amendment that New York City be chosen as the place for the permanent headquarters of the Institute.

Motion seconded.

MR. EGNER: Mr. President, that would mean that the

Secretary of this Association would have to move, and will have to live in New York. I think the first motion was the best—to leave it to the incoming officers. If the amendment is carried, whoever is Secretary will have to go to New York to live, or else that gentleman cannot be Secretary. That is all there is about it. I hope that the amendment will be voted down. It will not cost a great deal to move those books and things. I have moved a whole lot more than the Institute has to move a good many times, and it was never damaged, or anything like that. I hope the amendment will be voted down.

MR. J. DELL: Would it not be proper, Mr. President, to have an Assistant Secretary, and have him reside at the permanent headquarters? Then the Secretary elected from time to time would not necessarily have to live at the permanent headquarters if he held the place.

THE PRESIDENT: There is no provision made for an Assistant Secretary.

Are there any further remarks? If not, the motion will be on the amendment, that permanent headquarters be established for the Institute in New York City.

MR. D. McDONALD, Louisville: Mr. President, are we ready to vote on this question? It does not seem to me that we are. There is no report here of what we are going to keep in New York. There is no report here as to where we are going to have our permanent headquarters or what is to be done there. It seems to me that the matter is before the Institute in very indefinite shape. It seems to me necessary to leave that for the future, to leave it to the Governing Board for the present, for them to report on at the next meeting. I do not think that we are ready to vote on such an important matter as that. We cannot vote to move the headquarters to New York without knowing what that involves. Does that mean that every meeting will have to be held in New York City? It seems to me that we ought to leave that to the Board, or to a competent committee to put in shape so that we can take intelligent action.

MR. MITCHELL: It does not matter what we have to keep

at the headquarters. New York City is a good place for it. New York City has plenty of good men to take care of it.

THE PRESIDENT: Gentlemen, are you ready for the question? All in favor of the amendment as stated by Mr. Mitchell, that the permanent headquarters be established in New York City, signify by saying "Aye." Contrary minds by the same sign. The "Noes" have it, and the amendment is lost.

Now, gentlemen, we will put the original motion, that the matter of establishing permanent headquarters be left to the incoming officers with power to act.

MR. D. McDONALD, Louisville: Mr. President, just a moment before that motion is put. With power to act for how long? I move to amend that, if it is in order, that the power to act shall only hold good until the next meeting of the Institute.

THE PRESIDENT: You can change it at any time. All in favor of the motion as stated will signify by saying "Aye." Contrary minds, "No." The motion is carried, and the matter is left to the incoming officers.

SECRETARY DUNBAR: It has been recommended that an extension of thirty days be given dilatory applicants in order to send in their applications to become charter members.

MR. SHELTON: Mr. President, I move that that be extended to December 1st.

THE PRESIDENT: As I remember, when that matter was under discussion before the Board, the original motion was thirty days be adopted, and afterwards I think it was agreed that it should be extended to December 1st. Are there any further remarks? If not, all in favor of the amendment offered by Mr. Shelton will signify by saying "Aye." Contrary minds, "No." Carried.

The original motion is that the matter be extended for thirty days. The vote is now upon the motion as amended, or that the recommendation as amended be accepted. All in favor of the motion as amended say "Aye." Contrary minds signify by the same sign. It is carried.

SECRETARY DUNBAR: It is recommended that no honorary member be chosen for two years, and at no time until after the name of the candidate for honorary membership shall have been before the Board for at least one year.

MR. MITCHELL: Move it be adopted.

Motion seconded.

THE PRESIDENT: Gentlemen, it is regularly moved and seconded that that be adopted. Are there any remarks? All in favor of the motion will say "Aye." Contrary minds, "No." The motion is carried.

SECRETARY DUNBAR: That is all, Mr. Chairman, with the exception of the reports of the Secretaries of the three Associations that the applicants have been classified, with few alterations, as received. I think there were probably a dozen instances in which members applied for active membership who were classified for associate membership. The committee passed on those as their qualifications seemed to indicate.

THE PRESIDENT: Gentlemen, we will now listen to Mr. Doty's report for the committee on the question of dividing the Institute into sections for the different classes of work.

MR. PAUL DOTY: Mr. President and gentlemen, I have to present a report of the Committee on Proposed Sections for the American Gas Institute. The committee consists of Mr. Doherty, Mr. Donald McDonald and myself, and the report of the committee was prepared having in mind how to increase the value of our Gas Institute work.

REPORT OF THE COMMITTEE ON PROPOSED SECTIONS FOR THE AMERICAN GAS INSTITUTE.

The objects of this Institute are to amalgamate into one body the American Gas Light Association, the Ohio Gas Light Association and the Western Gas Association, and to facilitate co-operation between the various State and District associations that now exist, and to secure thereby a more rapid promotion and advancement of scientific and practical

knowledge in all matters relating to the construction and management of gas works in the manufacture, distribution and consumption of gas.

The first object, that of amalgamation, is now an accomplished fact by the vote of the members of the three associations named.

The second object, to facilitate the co-operation between the various State and District associations, can be accomplished in accordance with article 49 of the Constitution providing for the affiliation of local associations.

The Board of Directors may, in its discretion, make with any one, or all, of the District and State Gas Associations now existing, or hereafter to be formed, that will agree to thereafter confine its elections to membership to persons directly identified with gas interests within the District or State whose name it bears, to consult with the Institute before undertaking any original work, and to do each year in co-operation with the Institute a certain amount of original work, agreements providing for co-operation between the Institute and such associations. Each and every District or State gas association with which such agreements are entered into shall be entitled to elect one of its members a member of the Board of Directors of the Institute, the member so elected to be in addition to those named in Section No. 21, provided that the number of such associated directors shall never exceed one-third of the total membership of the Board. Should the Board of Directors provide for an Executive Committee, this committee shall include in its membership one man from each of the affiliated associations as long as the number of such associations does not exceed six. Thereafter there shall be on the Executive Committee at least six men who are members of affiliated associations, and have among them membership in at least six such associations.

The third object, to secure a more rapid promotion and advancement of scientific and practical knowledge in all matters relating to the construction and management of gas works, and the manufacture, distribution and consumption of gas, is really the chief object of the Institute, which was born of the desire to accomplish better association work. The

framers of the Constitution recognized the complex nature of the gas industry in their recital of the third object. It is evident there are men engaged in construction work, and there are men engaged in the management of gas properties, and men engaged in the manufacture, distribution and consumption of gas. It is also recognized that there are men who are associated in pursuits which constitute branches of gas engineering, and are, therefore, qualified to assist in promoting the objects of the Institute. There is, therefore, provision made for active and junior members, and associate members. It is recognized that it is impossible to consider all matters of importance in so complex an industry in one short annual session. It is also evident that all of the officers and employes of a company cannot be absent at one time in attendance at a convention in a distant city. Your committee, therefore, was appointed to consider the question of sectional divisions for the consideration of special lines of work, and that these sectional divisions will have their own sectional officers, and would hold national conventions under the direction of the Institute, and that all members of these sectional divisions shall be members of the Gas Institute. It is proposed that there shall be the following classes for active and junior members:

Class A—Engineers, Managers, Superintendents, Consulting Engineers.
Class B—Secretaries, Treasurers, Accountants.
Class C—Commercial Managers, Advertisers.
Class D—Chemists.

Additional classes can be provided should there be a necessity for including other specialists, such as attorneys for gas companies, heating and ventilating engineers, etc.

The Directors of the Gas Institute shall have power to consolidate any two or more sections temporarily.

If the recommendation of the committee shall be adopted that the Institute be divided into Sections, then the committee recommends that the Board of Directors be authorized to appoint a member of the Institute to be the First Chairman, and to take charge of the organization of each of the Sections

which the Institute shall finally authorize, and to provide for the time and place of the first meeting of each of the Sections.

The committee makes no recommendation for sectional organization of associate membership. In view, however, of the fact that there exists already well organized associations engaged in work closely related to the gas industry, such as the Illuminating Engineering Association, the Natural Gas Association, the National Commercial Gas Association, we recommend that the Board of Directors be authorized, in its discretion, to make with any one or all of the associations named above, or hereafter to be formed, that will agree to consult with the Institute before undertaking any original work relating to the gas industry, and to do in co-operation with the Institute a certain amount of original work, agreements providing for co-operation between the Institute and such associations. Each and every affiliated association with which such agreements are entered into shall be entitled to elect one of its members a member of the Board of Directors of the Institute, governed by the same provisions as now govern Article 49 of the Constitution.

Your Committee submits as a supplement to this report a number of subjects for investigation and report. A number of these subjects can be referred to the Chairmen of the sections, others can be referred to special committees of the Institute for investigation, while others can be referred to the association which will affiliate with the Institute.

The Committee believes that better association work will result from the adoption of this plan, and respectfully recommends that your Board of Directors be and they are hereby authorized to do all things necessary to this end.

Respectfully submitted,

PAUL DOTY, *Chairman.*"

SUPPLEMENT TO THE REPORT OF COMMITTEE ON SECTIONAL WORK.

NEW BUSINESS.

1. *Advertising:* A further analysis of theory of advertising and data on the results secured by different methods

and mediums; also a tabulation of the cost of different forms of advertising, newspaper space, booklets, circulars, letters, fancy cards, etc.

2. *Cost and Profitableness of Various Classes:* Compilation of New Business methods and data on the degree of profitableness of different classes of business and especially different classes of industrial fuel gas business.

3. Outline of methods required to determine cost of different classes of business, and especially that portion of the investment which is now termed 'Investment Required Later.'

5. *Revenue From Various Classes:* An analysis to the greatest degree possible of our receipts, showing revenue secured from (a) different classes of residences; (b) different classes of business houses; (c) different classes of factories; (d) different classes of industrial fuel users—such as hotels, restaurants, foundries, machine shops, brass workers, etc. This data can probably be best secured from such companies as have adopted the Hollerith System of Mechanical Tabulation.

Appliances.

27. *Domestic Fuel:* A complete investigation and aging test on present domestic water heaters available to enable us to select that type of water heater which gives a higher commercial economy. Initial economy is not of such importance as maintained economy, and all heaters now on the market seem to age in efficiency, and it is desirable to secure a heater with a high initial efficiency, and the longest possible period in the depreciation of this initial efficiency.

44. *Industrial Fuel:* Investigation, experimental work and complete report embracing the working drawings to enable each Gas Company to build high temperature gas furnace for special industrial fuel gas work.

47. Investigation, experimental work and complete report on best bake oven available, together with working drawings on construction of such bake oven. If the same is not on the market it must be built.

48. Experiments to determine best type of assayers' furnace

and furnace for similar work; report to embrace working drawings if furnace is not available on the market.

53. Investigation and development of better self-lighting furnaces.

54. Investigation and report on the effect of burning gas by use of forced blast, and instructions to determine when the use of forced blast is desirable or necessary.

30. *Lamps:* A determination and report showing what type of high candle power gas street lamp should be adopted and the faults of such high candle power lamps which are impracticable. Also experiments to raise the efficiency of these appliances.

46-a. An investigation and report to enable each Gas Company to select proper incandescent Bunsen burners and mantles.

52. Investigation of best by-pass for use on window and outdoor lights, and if satisfactory by-pass cannot be secured, experimental work will be conducted for the production of a double by-pass and arrangement made with some of the present manufacturers for their production.

Generation.

22. *Coal Gas:* Under what circumstances and conditions as to coke prices, etc., shall we use coal instead of coke for bench fuel, and vice versa.

24. A bulletin of instructions on care and operation of regenerative benches, which is so concise and simple that it can be placed in the hands of the retort house foreman, and by this means secure proper operation of benches.

38. Experiments to determine best and cheapest methods for carbonizing coal, either by the adoption of apparatus now obtainable on the market or the construction of new apparatus.

18. *By-Products:* A complication of results being secured in different Companies in yield of tar per ton of coal and a determination of why such a great variation now exists.

26. Experimental work to determine the value of tar for fuel purposes and a bulletin of instructions showing type of tar burners and burners to be used to obtain best results.

28. An investigation and a bulletin of instructions on gas works operation to insure greater recovery of ammonia. Some plants are now recovering four and five times as much as others and the reason for this difference in recovery is not apparent.

57. Investigation and experimental work with report for securing tar comparatively free from lamp black.

29. *Purification:* Experiments to enable us to use ammonia for purification instead of iron oxide, or an investigation and a bulletin of report which will enable us to remove the maximum amount of sulphur from our gas by use of ammonia.

23. *Candle Power:* Definite instructions, which establish standard methods for measuring and reporting candle power of gas. The methods now employed are so lacking in uniformity as to render present reports of little value for purpose of comparison.

21. *Water Gas:* A bulletin of instructions on methods of determining value of gas oil showing proper means of checking uniformity of supply and value for gas making by test of gravity and also by fractional distillation.

31. Investigation of the cheapest and most satisfactory means of increasing capacity of present water gas machines.

32. A determination of best methods to remove oil from water gas and thus increase the efficiency and life of our oxide purifying material.

37. Investigation, experimental work and complete report embracing apparatus required, with working drawings for same, together with complete instructions for operation to enable us to substitute coal tar for gas oil in making water gas.

41. The present loss of fuel in the type of water gas machine now in use is excessive, and whatever means are necessary to curtail this loss should be taken. This will involve considerable experimental work.

34. *General and Experimental:* Investigation supplements by experiments, followed by a complete report on best method for scrubbing napthalene from gas.

35. Investigation and experimental work and complete

report embracing the design of apparatus with working drawings for the removal of water vapor from gas.

36. Investigation and experiments, if necessary, with complete report to enable all companies to isolate hydrocarbons in their gas and determine quantity of each hydrocarbon gas present.

39. Determination of loss of candle power which will result from method recommended for removal of water vapor from gas.

56. Investigation and report on proper means for calculating and measuring calorific value of gas, and the provision of adopting the feature of calorific value in our retorts and in our object of manufacture giving it as great attention as we now bestow upon candle power.

By-Products.

8. *Coke:* An investigation to determine cheapest and best way to handle and store coke to insure dry coke for the market. Also comparison of cost of different companies for handling, crushing, screening and for city delivery.

9. An investigation of present fuel burning appliances adapted for the use of coke, and a determination of the class of apparatus best suited to cultivate our coke market. Also the sizes of coke we should provide for the market and the discrimination of these sizes by names which may eventually be adopted universally. In connection with this, investigation should cover the proper type of coke crusher, screens, etc., to be used to insure lowest labor cost and least waste.

19. Collect data showing present market for the disposal of breeze, and by investigation and experimental work find new markets which will give us a better price for this product.

25. An investigation and report showing the value of coke compared with retail price of hard and soft coal.

This investigation should show at what price coke could be sold in comparison with other fuels, and also show why such a variation between cost of hard coal and coke should exist as at present on our various properties.

40. *Tar:* Investigation, experimental work and complete

report showing apparatus to be used, with working drawings for the erection of same for the removal of water from tar.

45. Investigation, experimental and research work, with complete report to enable each Gas Company to find new uses for tar and enable them to avail themselves of markets already developed.

46. Experiments to show cost and durability of tar macadam for streets.

6. *Ammonia:* A thorough investigation and a comprehensive report covering the commercial and engineering work required to determine how we can sell our ammonia to obtain better results. This will probably necessitate manufacturing certain refined ammonia compounds.

Distribution.

33. *Mains:* Experiments to determine the proper law for flow of gases in pipes, and the effect of bends, changes in direction through valves, and other information necessary to enable us to compute conductivity of a distributing system or to determine size of pipe required to secure desired conductivity.

49. Investigation and reports on results secured from the use of universal pipe.

16. *Meters:* An investigation and experiments to show cost, together with working drawings of best apparatus obtainable for portable testing of gas consumers' meters.

42. Investigation, experimental and research work to secure further development in present meters and induce manufacturers to build this type of apparatus to better meet our present conditions of handling and service without such excessive maintenance cost.

43. Investigation and report on the advisability of substituting a cast iron case for meters with iron connection instead of a tin meter case and lead connections. The development of high capacity meters of small sizes seems to promise the possibility of this change.

10. *Transportation:* Investigation and report on advisability of substituting automobiles for horses and wagons,

showing type of automobile which should be used, purchase price of same, probable operating cost, and data on reduction in cost of labor through use of swifter means of transportation.

11. *Leakage:* A determination of actual leakage on gas mains and to what extent we are warranted in attempting to lessen actual breakage and best means to insure doing so. Also the desirability of changing present type of joints to that of improved patent joints, such as universal pipe joints, or the Dresser or Hammond coupling as used by Natural Gas Companies.

17. A bulletin of instruction based on actual experiments regarding best methods to determine presence of artificial gas in sewers and how to locate entrance point to sewers.

12. *Pressure and Maximum Demand:* Investigation and report upon which all engineers can agree upon the best method of increasing conductivity of distributing system, whether by use of high pressure lines or raising pressure on our present distributing system by use of fans or positive blowers, and the conditions which will determine advisability of establishing a fan or a positive blower; it being understood that the fan is best for large volumes and low pressures, and the positive blower most efficient for high pressures. What is the dividing line between fan blowers and positive blowers regarding pressure?

14. Investigation of the maximum demands occasioned by different consumers so classified to give us proper data on which to figure extensions and increases in our distributing systems.

50. Experimental work to obtain suitable house pressure regulator.

51. Investigation and experimental work and complete report on the desirability of raising our minimum street main pressure, theoretical effect on leakage, check by actual experiment and graphic curves showing improvement which will result in pressure regulation.

13. *Electrolysis:* A continuation of investigation on electrolysis to be made so detailed and to be checked by experimental work with conclusions drawn so that each

company will be properly instructed how best to protect his system from electrolytic action.

4. *Accounting:* More complete instructions regarding classification of accounts and means for securing uniformity in classification by all companies. This must insure the same interpretation of classification.

8. Detailed instructions of how to keep records, collect and voucher invoices, make division of accounts, and all other necessary data.

MR. D. McDONALD, Louisville: Mr. President, I move that the report be adopted as read.

Motion seconded.

THE PRESIDENT: Gentlemen, it is open for discussion. Are there any remarks? All in favor of the motion as stated will signify by saying "Aye." Contrary minds, "No." The motion is carried.

Gentlemen, I want to announce the committee on next place of meeting as follows: Mr. Witherby, Mr. T. C. Jones and Mr. J. B. Howard. It is on the schedule for that committee to report on Friday, but a report can be received whenever they are ready.

Is the committee on nomination of officers ready to report?

MR. PRATT: Mr. President, I will speak for the committee as the Chairman does not seem to be present. I would say that the committee has had no meeting, and the Chairman of the committee is not present. I think that the committee would prefer to have the time extended until tomorrow morning in order to more fully secure knowledge of the general wishes and desires of the different members before making any recommendation to the Institute.

THE PRESIDENT: I think that is very wise. If there is no objection, the time will be extended.

Is Mr. Cowdery ready to report on Mr. Faben? If so, we will listen to the memorial prepared by Mr. Cowdery with reference to Mr. Faben.

The following in memory of the late Charles R. Faben was read by Mr. Cowdery.

A PERSONAL TRIBUTE TO CHARLES R. FABEN.

Before proceeding with the first meeting of this new organization it seems appropriate to offer a brief testimonial to one who through his membership in the Governing Board, had much to do with the merger of the old gas associations into the American Gas Institute and who, had he lived, would undoubtedly have been with us today, assisting in the proceedings of this new association.

On the 28th of August the gas fraternity received the sad news of the death of Mr. Charles R. Faben, of Toledo, Ohio. The writer of this sketch will not dwell upon the historical record of the deceased as a business man, but speak more of him as he was known to his friends and acquaintances in a personal and social way. That "Death loves a shining mark" we have oft been told, but this does not in the least degree mitigate the deep sorrow and personal loss we all feel in having one whom we dearly loved so ruthlessly torn from our midst.

There is really no need of offering external evidence of our great feeling of grief at his demise; for in the heart of every member of this Institute, including those present as well as the absent ones, and including those who knew him intimately as well as those who simply had a business association with him, there is a genuine sadness and feeling of personal loss greater than it is possible for them to express.

To one who knew him for so long a time and so intimately as the writer, this feeling of personal loss is greatly intensified. It was my good fortune to have been associated with him in social as well as business companionship, and there are few, I think, aside from those of his immediate family circle, who have been afforded a better opportunity to judge of his lovable character and personality.

Omitting any special or detailed reference to his business career, of which much has already been written and spoken, let it here suffice to say, in order that we may think only of his personality, that the gas fraternity and its individual members have lost a friend, who was a sound business man and an ornament to the profession to which he belonged, and

to which he so willingly and intelligently gave of the best that was in him.

His modest and unassuming life was well filled with high honors bestowed upon him because of his real worth. Competent to an exceptional degree, industrious to a fault, clear-headed, fair and just in all his dealings, he was sought out by his friends and associates for many positions of honor in the Gas Association work. I feel safe in saying that few men ever lived who cared less for the plaudits of his fellows than did Charles Faben. He worked diligently for them and for the interests they represented. He felt thoroughly satisfied in knowing that he had their love and esteem. In all his valuable career as a member of the various associations, as well as in the official capacities connected therewith, he seemed to lose entire sight of his own personal aims and interests in his sincere efforts to promote the general welfare of the gas industry. In his case, the office surely sought the man. He was a worker, not a theorizer only. The question of what degree of glory might shine upon him for any act committed or work done was a thought far remote, if ever entertained by him. The good that he did for the gas fraternity, generally, will surely live after him, as his kindliness and gentleness toward his friends and acquaintances will long be cherished by them. "Fortune favors the brave" is an old adage, and particularly well exemplified in the life of our deceased brother. "Charlie" Faben, as he was called, was born in New York City, April 3, 1854, and throughout his early life lacked many of the opportunities for rapid business advancement which so materially assist a young man in his later life. He was not offered the opportunity of a higher scholastic education, but was plentifully endowed with that more important quality, common sense, a potent factor in the struggle of life of all who must make for themselves all that they are to possess. He possessed it to a marked degree, and it supported him well during the more unfortunate periods of his personal and business life. He learned that obstacles were to be overcome by grappling with them, and the many trying, though successful struggles, in his early and later life bear testimony of the caliber of man that he was. The early

lesson he learned that no man can afford to secure a result at the expense of his manhood, no matter how rich it may be, served as his golden rule, and he followed it religiously throughout his life.

At the outset, circumstances in many instances make or mar a man. In his case he either *made* the circumstances or required them to prove but stepping stones in aiding him in his work in life. By dint of hard work, perseverance and skill he rose to a high and respected position in life. He throttled the unfavorable conditions that surrounded him. To work straight ahead was not enough for him. His work was straight ahead, but put in at the right time and in the right way. The results obtained by him are well known to members of this fraternity and to his other friends. He was not accustomed to take things for granted. He early determined to become pre-eminent in his chosen profession. His heart was filled with quiet, productive enthusiasm in his work. He had the real essence in his make-up for the attaining of a great success. He loved to delve into the very depths of the detail that had to do with his work. Different vocations require a different quality of intellect rather than a difference in quantity. He had the good judgment to choose one of the vocations that fitted his intellect well, and if his life had not been so abruptly ended, his ultimate success would have been many fold greater.

His efforts were not for glory, and to be simply called successful. He strove more as a man who had a great desire to accomplish something which had never before been done, although from that which was visible in his every-day life this strong feeling and character was not readily noticeable. Those few only who were intimately associated with him really knew him as he was and as he felt. He worked and lived on the plan that a man must do something really noteworthy in order to be entitled to an exalted position among his fellows, and he for one was willing to let the glory of his achievements take care of themselves.

Another of his chief characteristics was his apparent absence of self-assertion, but with the happy faculty, however, of proving assertive in his thought and work, nevertheless. He

spoke only that which he believed to be true. This was so well recognized by his colleagues that whenever he did take a definite stand on any subject or enter into any discussion, his perfect fairness and truthfulness carried great influence favorable to the side on which he was arrayed.

He had breadth of thought, warmth of heart and unbounded humanity. His certainly was a lovable character.

This organization and its individual members have indeed lost a true friend and invaluable co-worker whose association has ever been marked by an unfaltering devotion to the interests involved. His strict integrity, his kind and generous nature, his simplicity and his fidelity to loyalty to his friends, had won for him the affectionate regard of all ; while his excellent judgment and wide experience, coupled with his personal lovable qualities and his keen sense of honor and love of fair play, rendered his counsel of priceless value to his associates, and earned for him their proud esteem.

We certainly feel his loss deeply, and sympathize sincerely with his bereaved family. We know how he worshiped his his home life with wife and children. We can feel how they must grieve at the unkind fate that has thus stricken their home and left great sorrow in its wake ; but it may cheer their aching hearts somewhat to know how he was revered by his friends, and to what an exceptional degree the departed husband and father was enshrined in the affections of his professional associates.

MR. KEENE : I move that Mr. Cowdery's memorial be spread upon the minutes, and that a copy thereof be sent to the family.

Motion seconded.

THE PRESIDENT : Gentlemen, it is regularly moved and seconded that the memorial read by Mr. Cowdery be spread upon the records of the Institute, and that a copy be sent to the family. All in favor of the motion as stated will signify by saying "Aye." Contrary minds, "No." It is carried.

We will now hear the report of Mr. Forstall on the Gas Educational Fund.

MR. A. E. FORSTALL : Mr. President, as the Institute by

its action this morning became a subscriber to the fund, it seems only proper that it should have the report presented to it.

EIGHTH ANNUAL REPORT OF THE TRUSTEES GAS EDUCATIONAL FUND TO THE SUBSCRIBERS TO THE FUND.

To the Subscribers of the Trustees Gas Educational Fund:

GENTLEMEN: The Trustees appointed at the Twenty-sixth Annual Meeting of the American Gas Light Association, held October 17, 1898, to administer the Educational Fund formed by your subscriptions, submit the following report as to the work done from October 1, 1905, to September 30, 1906.

The Treasurer's report shows that the amount of subscriptions has again been slightly increased during the year. This increase in income has not, however, been sufficient to enable the Trustees to do more than carry on the work with the membership of the class kept down to the limit of one hundred and fifty (150) for a maximum, which was fixed two years ago on account of its having been found impossible to take care of a larger average membership than that corresponding to this maximum. As was stated in the report for last year, if only one-half of the gas companies in the United States and Canada that are not now subscribers to the fund would make subscriptions bearing the same proportion to the business done as do the subscriptions now in force, the income of the Trustees would be doubled. This would enable the membership of the class to be enlarged, and also make it possible to undertake research work that would be of benefit to the gas industry. It is to be hoped that the organization of the Gas Institute will produce a condition of affairs that will bring about increased subscriptions to the Educational Fund.

During the year a start has been made upon the work of getting in shape to be published, properly classified and indexed in a single volume, all of the answers sent out to different sections of the class since the work was taken over by the Trustees, so that these answers will be more readily

available to any one wishing to use them than they are at present. This volume should be ready for issue in the spring of 1907.

The work of the Correspondence Class has been carried on throughout the year. The members of the Section of 1906 having finished the three years' course, their connection with the class ceased on March 1, 1906. The Section of 1909 started work on January 2, 1906, with a membership of thirty-nine.

The number of members in each section at the beginning of the year, and the changes that have taken place during the year, and the names of the members of the class who have completed the course during the year, are shown in detail on the Secretary's report, which is appended.

The Section of 1907 now contains twenty-two members, the Section of 1908 twenty-one, and the Section of 1909 forty-two, making the total membership in the regular class eighty-five. Four special students are receiving the questions and answers with the Section of 1909.

The card index of the principal articles published in the American Gas Light Journal, Progressive Age and the Journal of Gas Lighting has been kept up during the year. It is in constant use and is available and valuable for any subscribers wishing to look up particular subjects.

The Surplus Fund is made up of a contribution of $1,000, of subscriptions paid in advance of the time when they are due, of unexpended balances and of interest received on investments. The proper portion of the advance subscriptions will, of course, be drawn out each year to meet expenses, but the unexpended balances and the interest will accumulate into a fund, which will be available to assist in carrying on the work in case all the present subscriptions are not renewed when they expire.

Respectfully submitted,

TRUSTEES GAS EDUCATIONAL FUND.
WALTON CLARK, *Chairman.*
ALFRED E. FORSTALL, *Secretary.*

Treasurer's Report for Year Ending Sept. 30, 1906.

Condition of Subscriptions.

		For Year 1905-1906
Total of old subscriptions holding over from original five-year period	$211.16	$118.58
Total new subscriptions reported Sept. 30, 1905	22,276.00	4,455.20
Subscriptions received since that date	770.00	154.00
	$23,257.16	$4,727.78
Received from subscribers during year	$4,341.00	
Payments not applicable to year	476.00	
Total paid in by subscribers since Sept. 30, 1905, and available for year	$3,865.00	
Paid in previous to current year on account of 1905-1906 subscriptions	467.78	
Total paid in by subscribers available for this year	$4,332.78	
Still to be paid for this year	395.00	
		$4,727.78
Dues received for membership in special class		15.00
Sale of seven sets of questions and answers for one year		35.00
Total amount available for year		$4,777.78

Statement of Income and Expense.

Total amount available for year....		$4,777.78

Expenses.

Secretary's salary..................	$3,000.00	
Office rent........................	300.00	
Printing, stationery, postage, etc...	675.22	
Periodicals and binding...........	16.48	
Fire insurance on books...........	12.17	
Cuts used in illustrating answers...	35.05	
Total expense for year........		$4,038.92
Balance.........................		$738.86
Depreciation on furniture.........		14.76
Surplus on year's operation....		$724.10

Cash Account.

Received from subscribers since September 30, 1905, current fund....	$4,341.00
Interest for one year on $2,000 Binghamton Gas Works 1st mortgage 5% bonds......................	100.00
Interest for one year on $1,500 Atchison, Topeka & Sante Fe R. R. general mortgage 4% bonds	60.00
Interest for one year on $1,500 New Gas Light Company, of Janesville, 1st mortgage 5% bonds (guaranteed by The United Gas Improvment Co.)....................	75.00
Interest for one year on $1,000 Omaha Gas Company 1st mortgage	

5% bonds....................	50.00	
Interest on deposit in Knickerbocker Trust Co..................	69.20	
Sale of seven sets of questions and answers for one year............	35.00	
Dues received for membership in Special Class..................	15.00	
Total receipts for year........	$4,745.20	
Cash balance from last year	664.60	
Total to account for..........		$5,409.80
Expenses for year, paid...........		4,038.92
Balance		$1,370.88
Balance in Knickerbocker Trust Co., as per pass book, less checks unpaid	$1,360.88	
Cash on hand....................	10.00	
		$1,370.88

Surplus Fund and Investment.

Amount paid in by subscribers in advance	$1,250.98
Amount paid in by subscribers to Surplus Fund	1,000.00
Unexpended balance from 1898-1889	1,330.99
" " " 1899-1900	397.70
" " " 1900-1901	343.71
" " " 1901-1902	211.88
" " " 1902-1903	359.89
" " " 1903-1904	395.88
" " " 1904-1905	676.38
Interest on bonds to date..........	1,377.22
Interest on deposit in Knickerbocker Trust Co......................	148.74
	$7,493.37

Already Invested.

$2,000 Binghamton Gas Works 1st Mortgage 5% bonds	$1,930.00		
$1,500 Atchison, Topeka & Santa Fe R. R. Gen'l Mortgage 4% bonds.	1,513.75		
$1,000 Omaha Gas Co. first Mortgage 5% bonds................	1,000.00		
$1 500 New Gas Light Company, of Janesville, 1st mortgage 5% bonds (guaranteed by The United Gas Improvement Company).........	$1,500.00		
Furniture	132.84		
		$6,076.59	
		$1,416.78	

SECRETARY'S REPORT FOR YEAR ENDING SEPT. 30, 1906.

	Section of 1906	Section of 1907	Section of 1908	Section of 1909	Special Class 1907	Special Class 1908	Special Class 1909	Total
Members enrolled Oct. 1, 1905.............	24	29	49	..	1	2	..	105
Entered Class Jan. 1, 1906	..	..	..	34	..	..	5	39
Additions to Class since Jan. 1, 1906.........	..	..	..	40	..	..	1	41
Reinstated in Class during year............	..	2	5	.	.	..	..	7
	24	31	54	74	1	2	6	192
Resigned during year	..	1	2	2	..	..	..	5
Dropped from Class during year............	2	8	31	30	1	2	2	76
Finished course during year...............	22	..	..	..	..	..	..	22
	24	9	33	32	1	2	2	103
Total enrollment Sept. 30, 1906............	..	22	21	42	..	..	4	89

Applications on file for admission to class Jan. 1, 1907..... 11

NAMES OF STUDENTS WHO COMPLETED THE THREE YEARS' COURSE WITH THE SECTION OF 1906.

WALTER A. ALLISON, Philadelphia, Pa.
ALBERT M. BOYD, Philadelphia, Pa.
ROBERT W. BROWN, Philadelphia, Pa.
JOHN B. BYRNE, New Haven, Conn.
WM. A. CASTOR, Frankford, Pa.
HARRY B. CHRISTY, Philadelphia, Pa.
HENRY L. COLEMAN, Geneva, N. Y.
WILLIAM WALLACE CONKLIN, New Haven, Conn.
WILLIAM K. EAVENSON, Philadelphia, Pa.
HENRY A. GEIB, East Norwalk, Conn.
HUBERT D. GILLINGHAM, Wilkesbarre, Pa.
JAMES H. HOUSMAN, Jersey City, N. J.
EARNEST L. LOCKE, Waltham, Mass.
JOSEPH LUCENA, Philadelphia, Pa.
HUGH K. MACDOUGALL, Newark, N. J.
JOSEPH S. PARKER, Philadelphia, Pa.
FRANK F. SCHAUER, Kansas City, Mo.
ROBERT K. SEVERSON, Philadelphia, Pa.
JOHN R. STANTON, Germantown, Pa.
W. M. VAN ALSTYNE, Lockport, N. Y.
EDWIN WEISGERBER, East Orange, N. J.
HENRY A. WUEST, Brooklyn, N. Y.

In addition to these, MCK. J. SULLIVAN, Houston, Texas, answered all except the last set of questions, and HERBERT COPE, Philadelphia, Pa., answered all except the last two sets of questions.

MR. FORSTALL: I might say that the Surplus Fund now amounts at the end of seven years to $7,493.

The report is signed by Walton Clark, Chairman, and Alfred E. Forstall as Secretary.

MR. NETTLETON: Mr. President, I move that the report be accepted and published in the proceedings accompanied by the questions and answers sent out to the class during the year.

Motion seconded.

The President: Gentlemen, it is moved and seconded that the report be accepted and published in the proceedings of the Institute, together with the questions and answers. Are there any remarks. All in favor will signify by saying "Aye." Contrary minds, "No." It is carried.

Mr. Shelton: Before we adjourn, Mr. Chairman, I would just like to say that arrangements have been made to have a gas man's subscription dinner tomorrow evening at 7:30 in an upper room of the Auditorium, at ten dollars each. Put your names on my list, and you can get a receipt if you want it. I will be at the door, and Mr. Persons also.

On motion duly seconded and passed, the Institute adjourned until 2 P. M.

APPENDIX TO REPORT OF THE TRUSTEES GAS EDUCATIONAL FUND.

(This appendix was not read at the meeting.)

Seventh Series of Questions — Section of 1907 — Practical Class—American Gas Light Association.

1. What is crude oil? What is naphtha? What is gas oil?
2. Describe the putting into operation of a bench of retorts heated by a generator furnace, from the lighting of the fire to the putting in of the first charge, giving the precautions to be taken to prevent any injury to the setting.
3. Describe the cleaning of the washbox of a carburetted water gas apparatus, including the precautions to be observed to prevent the occurrence of any accident.
4. Give a description, illustrated by a sketch, of the manner in which to stop a small ragged hole in a gas holder sheet too thin to permit of tapping a thread.
5. What is the meaning of the term "latent heat of a

vapor" and what is the value of this "latent heat" in the case of steam?

6. What is the maximum amount of gas containing 320 grains of sulphuretted hydrogen, H_2S, per 100 cubic feet that can theoretically be purified by a bushel of purifying material containing thirty pounds of hydrated sesqui-oxide of iron, $Fe_2O_3 . H_2O$? It is assumed that no oxygen is present in the gas.

7. Give a description, illustrated by sketches, of some form of apparatus for, and the process of concentrating ammoniacal liquor, and state the conditions that render it advisable to so treat the liquor.

8. A cylindrical oil tank of the "cheese-box" type is 22 ft. 6 in. in diameter and 16 ft. 0 in. high. How many gallons of oil will it hold for each inch and each foot of its height and what will be its total contents when full?

9. Describe some form of calorimeter by the use of which the calorific value of gas can be determined by observation.

10. State two or more conditions making the use of pressure regulators on house piping, or of governor burners, of advantage.

11. If a 4-in. gas main will, under certain conditions of length of main, amount of pressure lost by friction and specific gravity of the gas, deliver 1,000 cubic feet of gas per hour, what amounts of gas will be delivered per hour under the same conditions by a 6-in. main and an 8-in. main respectively?

12. Describe the proper method of preparing and putting in a cement and broken stone concrete for foundations in dry or nearly dry earth.

(Answers to these questions are due October 1, 1905.)

Answers to Seventh Series of Questions—Section of 1907—Practical Class—American Gas Light Association.

1. What is crude oil? What is naphtha? What is gas oil?

Answer. Crude oil is petroleum just as it comes from the oil wells. It is a mixture of liquid hydrocarbons possessing different chemical compositions, specific gravities and boiling points (together with small quantities of other substances) and can be separated into these different substances by fractional distillation. It is found in nearly every country in the world, but the most important fields are in the United States, Russia and Peru. The specific gravity of the petroleum obtained in Pennsylvania and Ohio varies from .80 to .85 (or 45° to 35° Baumé), water being 1.00. The color also varies, but is generally dark claret by transmitted light and greenish by reflected light. The specific gravity of the crude oil found at Beaumont, Texas, is .91 to .92, or 24° to 22° Baumé. It is dark brown in color.

Naphtha is a general name given to that portion of the products of the fractional distillation of petroleum which comes off after gasoline has been driven off and before the fraction suitable for use as burning or lamp oils begins to come off. It is very volatile at ordinary temperatures and highly inflammable. It is practically colorless, though some samples show a decidedly greenish tinge by reflected light. Its specific gravity varies from .68 to .74, or 76° to 60° Baumé.

Gas oil is a general name given to that portion of the products of the fractional distillation of petroleum which comes off after the lamp oils and before the lubricating oils. It is too heavy and of too high a boiling point to use for lamp oil, but not viscous enough to make a good lubricant, and is chiefly valuable for the production of gas. Its color varies from quite light to very dark. Its specific gravity also varies, but will average about .84, or 37° Baumé. (Trustees.)

2. Describe the putting into operation of a bench of retorts heated by a generator furnace, from the lighting of the fire to the putting in of the first charge, giving the precautions to be taken to prevent any injury to the setting.

Ans. The method to be employed in putting into operation a bench of retorts heated by a generator furnace will depend somewhat upon whether the bench has just been built or reset, or is one that has been previously fired up and let down.

In the case of a new bench, or of one that has just been reset, it is necessary that all the brick work about the bench should be thoroughly dried, by being subjected to a low heat for a long time, before any attempt is made to heat it up to a working point. This drying cannot be hurried without injury to the bench, and at least two weeks should be allowed for it. It is effected by keeping a very low fire on the grate of the furnace, using about a bushel or two of coke at the start and keeping the fire about the same size afterwards. The clinkering door of the furnace should be left wide open, the object being to pass through the bench as much moderately warm air as possible so as to pick up and carry off the moisture. The primary and secondary air ports should be closed, and also the main dampers. When the fire is first made all the stoppers in the front wall of the setting should be removed, leaving the stopper holes open. An opening the size of one or two bricks headerwise should also have been left in this wall directly under the crown of the arch. As the main dampers are closed the warm air laden with the moisture picked up in the furnace and lower part of the setting escapes through these openings in the front wall, carrying the moisture with it, while if it had to pass all around the retorts and through the take-off flues it would become cool and deposit most of the moisture in these flues before it escaped to the chimney. After the furnace is dried the stoppers can be put in the lower openings and the warm air forced to travel farther along, and so on, until after a week or ten days the main dampers can be opened a little, the large opening under the crown of the arch closed up and the warm and now comparatively dry air drawn through the whole of the setting and the take-off flues, thus drying all portions of the bench.

After the drying out is completed the bench is brought up to working heat in exactly the same manner as a bench that has been let down after a certain amount of service, except that a new bench should be heated up a little more slowly than an old one.

For heating up, a slightly larger fire is built than is used for drying out. Either just before or immediately after this fire is started, any coke left in the retorts from previous working must be drawn, the retort mouthpieces closed, the secondary air ports closed, and all stopper openings and cracks in the brick work carefully plastered up so that no air can get into the bench except through the primary air flues and the clinkering door. The primary air ports are opened slightly, as are also the main dampers. The clinkering door, instead of being left wide open, as in drying out, is only left slightly ajar, since now the object is to have the fire heat the bench and not to have it heat an excess of air passing through the bench. It is necessary to leave the door open a little to admit air above the surface of the fire for the purpose of consuming any carbonic oxide (CO) that may be formed as soon as it escapes from the fuel, and thus prevent the formation of an explosive mixture of carbonic oxide and air in the upper part of the furnace and in the setting, since such a mixture, if allowed to form, would probably be ignited later and explode with more or less damage to the bench. It is also necessary that the surface of the fire should never be entirely covered with cold coke, some portion being always left hot and incandescent to ignite the carbonic oxide as soon as it meets the air.

The fire is gradually increased until at the end of from 48 to 96 hours it can no longer be fed through the clinkering door. The plates and water pan of the step grate are now put in, the clinkering door shut, the water started running on the grate, and the primary air ports and main dampers opened wider. The fire is fed through the filling door until the furnace is half full. If cold coke is used the precaution noted above of never entirely covering the hot surface of the fire must be carefully observed. If hot coke is used, this, of course, obviates any danger of a cold surface to the fire. As soon as the combustion chamber and lower retorts reach a good red heat and the carbonic oxide coming from the furnace is seen to burn at the nostrils when air is admitted to the combustion chamber, the secondary air can be turned on and the bench brought up to heat as rapidly as is necessary, the furnace still

being kept about half full of coke, being completely filled only a few hours before the bench is to be put in action.

As soon as the retorts reach a red heat they should be patched and charged with coal, the charge being left in until burnt out. The bridge pipe covers should, of course, be closed before the retorts are charged. When the bench is nearly up to its proper working heat, regular charging can begin, and when this heat is reached, the openings of dampers and primary and secondary air ports must be carefully regulated to the proper respective areas.

If necessary, an old bench can be put in action within sixty hours after the fire is first started, but it is best to proceed more slowly, if possible, and spend five or six days in bringing the heat to the working point. (Trustees.)

3. Describe the cleaning of the washbox of a carburetted water gas apparatus, including the precautions to be observed to prevent the occurrence of any accident.

Ans. There are two arrangements of washbox in water gas apparatus. In one the take-off from the washbox is on top, and in the other it is on the side, and connects directly with the scrubber.

The connection from the gas outlet on top of the superheater to the washbox varies in different forms of water gas apparatus. In most cases there is a lid on top of what is known as the oil heater connection, which can be opened to clean the oil heater.

When no gas heater is used, the take-off connection from the superheater has a handhole cross at the top of the superheater, connecting the vertical riser from the washbox to the outlet branch on the superheater.

When the washbox has a take-off on top, there is a valve between the washbox and the scrubber, which can be closed and thus shut off communication between the washbox and the scrubber. In this case, first open either the lid on top of the oil heater, or, in case there is no oil heater, the handhole on the cross; then shut off the overflow from the washbox to the seal pot, open the handhole on top of the washbox and fill the washbox with water. When the washbox has been filled,

draw off the water, open the handhole or manhole on side of washbox and remove the tar, etc.

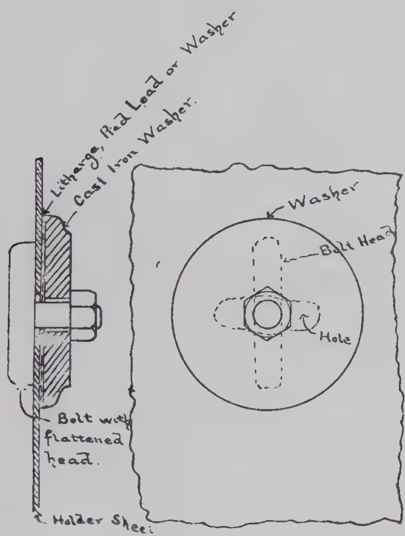
In case the washbox is joined to the scrubber by a side outlet, and there is no valve between them, the gas valve at the outlet of the scrubber must be closed. The stop cock on the overflow pipe from the scrubber must now be shut and the manholes on the scrubber opened, beginning with the one on top and working downward. The openings on the take-off pipe from the superheater to the washbox and the handhole on top of the latter must also be opened up, and the washbox filled with water until this rises into the standpipe above the top of the box. This, of course, involves filling the scrubber also to an equal height. Before emptying the washbox, the standpipe should be thoroughly cleaned of all carbon and tar to remove all danger of its catching fire and igniting any gas that might work back from the scrubber when the water is run out. If any of the carbon should happen to be on fire when it is scraped down, it will be extinguished by falling into the water, and before the water is drawn off, care must be taken to see that none remains unextinguished. After the standpipe has been cleaned, it should be plugged, just below the connection to the superheater, with either a bag of wet sawdust or a board cut to fit it fairly tight and plastered around the edge with fire clay to close all cracks. The object of this plugging is to prevent any gas that may work back from the scrubber from being ignited at the top of the superheater. The water can now be run off the washbox and scrubber, and the washbox opened and cleaned.

The differences between the two methods are called for by the necessity of seeing that the scrubber is thoroughly ventilated when it cannot be shut off, and of taking precautions to prevent the ignition of any gas that may still remain in the scrubber in spite of the ventilation given it. *In any case, the washbox and its connections must be thoroughly ventilated, and it should be provided that no fire comes near the washbox or its connections, or the scrubber, while they are open, and that no light is used about the work.* (Trustees.)

4. Give a description, illustrated by a sketch, of the

manner in which to stop a small ragged hole in a gas holder sheet too thin to permit of tapping a thread.

Ans. Make the hole oblong, say 1 in. to 1 1/8 in. long by 5/16 in. wide. Flatten the head of a 1/4 in. bolt until it is only 1/4 in. wide. Make a cast iron or other washer, 2 in. in diameter, with the hole a tight fit over the bolt. Mix a stiff paste of glycerine and litharge, red lead or any similar substance. Tie a string to the bolt, put the flattened head through the hole, give it a quarter turn, slip the washer, coated with the paste, over the bolt, grummet this with lamp wick, screw down the



nut until everything is drawn up tight, saw off the projecting end of the bolt, and the job is complete. (Trustees.)

5. What is the meaning of the term "latent heat of a vapor," and what is the value of this "latent heat" in the case of steam?

Ans. "Latent heat of a vapor is the quantity of heat which must be communicated to a liquid in order to convert it into a vapor without change of temperature." (*Maxwell.*)

When heat is supplied in sufficient quantity to a substance its temperature is increased up to a certain point at which, provided

the pressure is kept constant, it will remain stationary, no matter how much heat is applied, until the substance has completely changed its physical state; that is, if originally solid has become liquid, or if liquid has become a vapor. There is thus a certain amount of heat required to produce a change of physical state which does not produce any effect upon the temperature of the body undergoing the change. When heat was believed to be a material substance and therefore indestructible, the only way in which this apparent disappearance of heat could be explained was by assuming that the quantity not accounted for by change in temperature was hidden away or "latent" in the body ready to be given out again when the converse change of state took place. But under the kinetic theory of heat it is known that heat being merely one form of actual or kinetic energy can be converted into other forms of energy and cease to be heat, and that in the phenomenon of change of physical state that portion of the heat form of energy not employed in increasing the energy of vibration of the molecules (that is, increasing the temperature and producing heat) is employed in doing two classes of work, 1st, that of overcoming the pressure of the substance enveloping the body undergoing the change of state, as it expands through a space represented by the difference in volume between the two states, and 2d, that of overcoming the mutual attraction of the molecules for each other, and separating and rearranging them. In doing this work the heat form of kinetic energy is changed into energy of position or potential energy, the molecules of the body by virtue of the change in their position, due to the work expended on them, possessing the power of giving out energy or doing work by rushing together again when the converse change of state takes place, just as a heavy body raised to a high point possesses the power of doing work by falling to a lower point. Therefore the heat not employed in raising the temperature of the body ceases to exist as heat, and the term "latent" is inaccurate and misleading. But it was too firmly fixed in the vocabulary of physics under the old theory to be gotten rid of, and if the definition given above be understood as the proper one, no error can arise from the use of the term. The amount

of this latent heat varies with each vapor, and also varies for the same vapor as the pressure, and, therefore, the temperature of the vapor is varied. For water vapor or steam the latent heat at atmospheric pressure is 966.069 British thermal units and at a gauge pressure of 100 lbs. per square inch it is 876.511 thermal units, with intermediate values for each intermediate pressure. (Trustees.)

6. What is the maximum amount of gas containing 320 grains of sulphuretted hydrogen, H_2S, per 100 cubic feet that can theoretically be purified by a bushel of purifying material containing thirty pounds of hydrated sesqui-oxide of iron, $Fe_2O_3.H_2O$? It is assumed that no oxygen is present in the gas.

Ans. The answer to Question No. 6 of the Fifth Series of Questions shows that each pound of sesqui-oxide of iron, $Fe_2O_3.H_2O$, will combine with 0.573 pound of sulphuretted hydrogen, H_2S. Therefore, the thirty pounds of oxide contained in a bushel of the purifying material specified can theoretically absorb $30 \times 0.573 = 17.19$ pounds of sulphuretted hydrogen. Since the gas contains 320 grains of sulphuretted hydrogen per 100 cubic feet, it will contain 3,200 grains, or 0.46 pound (one pound equals 7,000 grains) per 1,000 cubic feet. $17.19 \div 0.46 = 37.37$, hence a bushel of purifying material containing thirty pounds of hydrated sesqui-oxide of iron will theoretically purify, during one exposure, 37,370 cubic feet of a gas which contains 320 grains of sulphuretted hydrogen per 100 cubic feet.

Obviously, the amount of gas that can be purified will vary according to the quantity of H_2S in the gas, and also according to the weight of $Fe_2O_3.H_2O$ contained in a bushel of material.

It is also possible by admitting oxygen with the gas and thus securing a continuous partial revivification, to purify more gas to an exposure than is indicated by the method of calculation given above. Unless oxygen is supplied, however, the duty actually obtained in practice from any material will always be less than the theoretical amount obtained by calculation, as it is impossible, under working conditions, to thoroughly saturate with H_2S all the $Fe_2O_3.H_2O$ in the material. (Trustees.)

7. Give a description, illustrated by sketches, of some form of apparatus for, and the process of concentrating ammoniacal liquor and state the conditions that render it advisable to so treat the liquor.

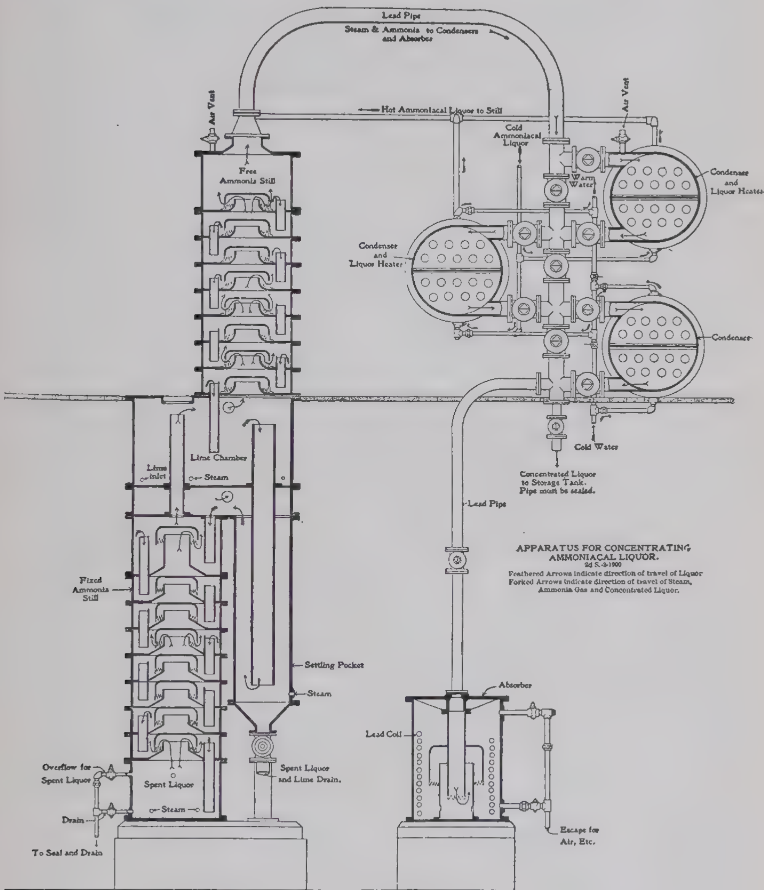
Ans. The apparatus used for concentrating ammoniacal liquor consists essentially of one or more "stills" in which the ammonia is driven out of the liquor either by heat alone or by the combined action of heat and a solution of lime, one or more "coolers," or condensers, in which the mixture of ammonia gas and water vapor passing off from the still is cooled and condensed into strong ammoniacal liquor, and one or more "absorbers," or catch vessels, in which any ammonia gas that escapes from the coolers is absorbed in cold water in a manner similar to that in which the ammonia is removed during the process of gas manufacture.

The apparatus illustrated in the cut is composed of two stills, three condensers so connected that either one, two or all three may be used at any time, and one absorber. In one of the stills the "free" ammonia (that is, the ammonia existing in the liquor either in an uncombined state or in the form of carbonates or sulphides, with occasionally a little cyanide and acetate), which can be driven off by heat alone, is expelled, the other still being used for driving off "fixed" ammonia or ammonia so combined (chiefly as chloride or thiosulphate with some thiocyanide and ferrocyanide, sulphate, sulphite, and in very fresh liquor thiocarbonate) that some alkali must be used in order to enable the heat to set free the ammonia. The liquor connections are so arranged that the liquor on its way from the storage tank to the stills passes through the tubes of either one or two of the coolers and thus absorbs, and returns to the still heat that would otherwise be imparted to the water used for cooling and lost.

In a more simple form of apparatus the two stills are combined into one, and the condensers replaced by a coil of lead pipe immersed in a vessel, through which water is kept flowing.

By referring to the cut, it will be seen that the stills are composed of a number of separate chambers, each of which has a circular opening raised above its bottom and so covered with a hood, the edges of which are serrated, that any gas or

vapor flowing through the opening can only pass out under the edge of the hood, which edge is kept sealed in liquor. The coolers are similar to the ordinary multitubular condensers used in gas manufacture, but the tubes should be made of



APPARATUS FOR CONCENTRATING AMMONIACAL LIQUOR.
2d S.-3-1900
Feathered Arrows indicate direction of travel of Liquor
Forked Arrows indicate direction of travel of Steam, Ammonia Gas and Concentrated Liquor.

some material that is not affected by ammonia and not of wrought iron or steel. The absorber is merely a washer in which the gas has to pass through the water twice. All connecting pipes which carry ammonia and steam, or strong liquor, should preferably be made of lead, and special stop

cocks made of materials not affected by ammonia should be used.

The apparatus is operated as follows:

A supply tank is kept filled with ammoniacal liquor while the concentrator is kept running. The water space of the first cooler is filled with the weak liquor to be concentrated, or this space in both the first and second coolers may be so filled, while that in the other cooler is filled with cold water. The absorber is also filled with water. Steam is then turned on at the bottom of the fixed ammonia still, the air being blown out of the apparatus by the air vents on the free ammonia still, the first cooler and the absorber, and the apparatus is heated up. When the proper temperature has been reached, say about 175° F. at the inlet to the first cooler, the liquor cocks are opened and liquor run from the supply tank through the cooler, or coolers, into the still. A current of water is also started through the coolers not being used as liquor heaters. The hot liquor running into the top of the still fills up the first compartment, overflows into the second, fills this up and overflows, and so on down through all the compartments of the free ammonia still into the lime chamber, through the lime settling pocket into and through the compartments of the fixed ammonia still, as indicated on the cut by the feathered arrows. The steam bubbling through the liquor, as it fills one compartment after the other, heats it more and more, until by the time the liquor has reached the lime chamber the free ammonia has all been driven off. Milk of lime added at this point decomposes the fixed ammonia compounds, and as the ammonia passes through the fixed ammonia still it parts with the remaining ammonia under the action of the heat and reaches the bottom of the still spent and ready to be run through the sealed overflow to the drain.

The steam and the ammonia gas pass upward, as indicated by forked arrows on the cut, bubbling through the liquor in each compartment, which in each case absorbs a little of the ammonia to give it off again at the higher temperature met with in the compartment next below, until finally the steam and the remaining ammonia gas pass out together from the top of the still and enter the coolers. As the mixture cools

the steam condenses, and in so doing absorbs the ammonia gas in greater and greater quantity as the temperature falls, until at the outlet of the last cooler most of the ammonia has been absorbed and the concentrated liquor so formed is drawn off to the storage tank. As it is not advisable to have the temperature at the outlet of the coolers reduced to too low a point, some of the ammonia gas is still unabsorbed at this point, but is caught by the water in the absorber, this water being kept cool by circulating cold water through the coil with which the absorber is provided. The liquor thus formed in the absorber should be drawn off and replaced by fresh water as soon as it reaches a strength of 2° Twaddell.

The strength of the concentrated liquor is tested occasionally and kept at the proper point by adjusting the flow of liquor and of steam. The more steam used for the same amount of liquor the weaker is the concentrated liquor. The more weak liquor used for the same amount of steam the stronger is the concentrated liquor. If too much weak liquor, or too little steam is used, all the ammonia will not be driven off from the spent liquor, which will carry some of the ammonia out with it from the still. When this is the case, the spent liquor running off will smell of ammonia.

Some hints as to the points to be watched in starting up, operating and letting down an ammonia concentrating apparatus will be found in a paper read before the Michigan Gas Association, at its Seventh Annual Meeting, by Mr. George Osius, and published in Progressive Age, Vol. XVIII, page 90, and the American Gas Light Journal, Vol. LXXII, page 449.

The principal condition rendering it advisable to concentrate ammoniacal liquor is remoteness from a market in which this liquor can be sold. In this case the reduction in cost of transportation owing to the concentration becomes an important item in permitting the ammonia to be sold at a price that renders it worth handling. It has been stated that a works carbonizing as low as 750 tons of coal per annum can net a profit from concentrated ammonia that will pay at least 15% interest on the cost of the necessary apparatus. Of course, this figure depends somewhat on the location of the works

and upon the amount of money put into the apparatus. (Trustees.)

8. A cylindrical oil tank of the "cheese-box" type is 22′ 6″ in diameter and 16′ 0″ high. How many gallons of oil will it hold for each inch and each foot of its height and what will be its total contents when full?

Ans. The area of a circle 22′ 6″ or 270″ in diameter is, as obtained from the tables of circumferences and areas of circles, 57,256 square inches, and therefore the tank will contain a volume of 57,256 cubic inches for each inch of its height. An American gallon has a volume of 231 cubic inches. $57,256 \div 231 = 247.86 +$ or each inch in height of the tank will contain 247.86 gallons of oil.

Each foot in height will contain $247.86 \times 12 = 2974.32$ gallons, and the total contents of the tank when full will be $2974.32 \times 16 = 47,589$ gallons.

Using the contents per inch and per foot, determined as above, a table should be prepared for each oil tank at a gas works, showing the total contents for any height to which it is filled with oil from 1″ to the full height. (Trustees.)

9. Describe some form of calorimeter by the use of which the calorific value of gas can be determined by observation.

Ans. The calorimeter that is most commonly used in this country for determining by observation, the calorific value of gases, is an improved form of the Hartley Calorimeter, designed by Hugo Junker, and known as the Junker Calorimeter. It acts by transferring the heat developed by the combustion of a measured quantity of gas to a measured quantity of water which flows at a constant rate through the apparatus.

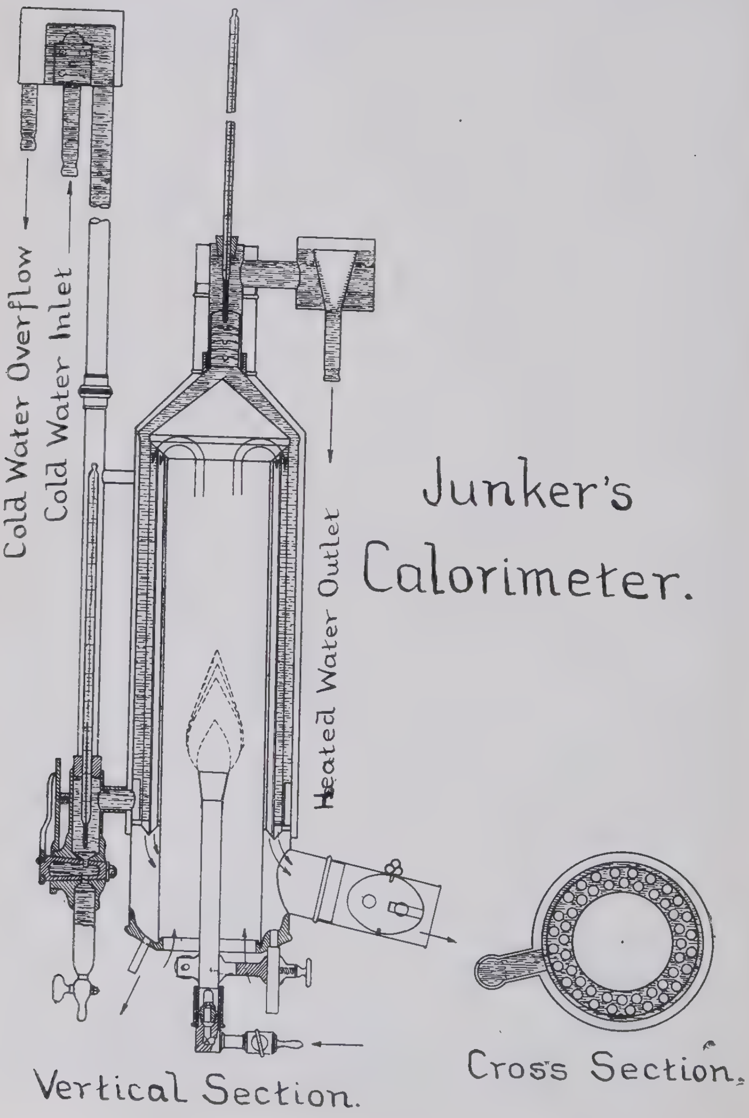
The calorimeter itself is an annular vessel made of two concentric copper cylinders, the outer cylinder having a diameter of about seven inches and the inner one a diameter of about four inches. To the top of the outer cylinder is fitted a conical hood which closes the whole top of the vessel, except for a circular opening left at the apex of the cone. A smaller hood which begins as a frustrum of a cone with its base

upwards and then changes to a cone with its apex upwards, is attached to the inner cylinder so that the annular space is continued up between the two hoods and the space within the inner cylinder is shut off at the top from this annular space. The bottom of the inner cylinder is left open and the bottom of the annular space is closed by a ring. At a distance of four or five inches above this ring is fastened another ring forming a water-tight partition which divides the annular space into two compartments. Through the upper one of these two compartments pass a number of small copper tubes, the upper ends of which are fastened to the diverging cone of the inner hood while the lower ends are fastened to the partition described above. The joints between the tubes and the hood and partition must be water-tight.

Into one side of the outer cylinder, just above the bottom of the upper compartment, opens a copper pipe set at a right angle to the axis of the cylinders. This pipe enters the side outlet of a tee piece set with its run vertical and about two inches from the cylinder. From the lower outlet of the tee the pipe is dropped a short distance and then passing around a U-shaped turn rises to a height of about 20″ above the top of the annular vessel and ends in a small cistern or cup formed inside of a larger one, both cups having a common support by the pipe. To the part of this bottom covered by the small cup is attached a corrugated nipple, over which a rubber tube can be slipped, and a similar nipple is fastened in the space outside of the small cup. The upper outlet of the tee is closed by a rubber cork pierced for the insertion of a thermometer. A stop cock provided with an arrow-shaped handle, moving over a graduated quadrant, is placed between the tee and the bend. Opposite the opening of the pipe in the outer cylinder is placed a baffle plate forming a small annular space extending completely around the cylinder, the object of which is to cause the water entering through the pipe to be uniformly distributed all around the annular chamber.

To the circular opening left, as described above, at the apex of the outer hood is fitted a copper tube provided with several baffle rings with centre openings. This tube ends in a tee piece, the upper end of which is closed by a cork pierced for

a thermometer, and from the side outlet of this tee runs a pipe which ends in and supports by its side a cup. Inside the cup is a funnel ending in a nipple for tubing, which passes through and is fastened with a water-tight joint to the bottom of the cup.



On one side of the lower compartment of the annular space is an elliptical opening leading into a tube of the same cross section. Provision is made for the insertion of a thermometer into this tube as close as possible to the outer cylinder, and it is also fitted with an ordinary stove pipe damper. At a point diametrically opposite to this tube a small tube is tapped into the bottom ring, and directly under it is tapped in a rod which serves to support the burner through which the gas is consumed.

To prevent loss of heat by radiation the whole of the body of the calorimeter above a point an inch or two below the bottom of the upper compartment is jacketed by a highly polished nickle-plated copper cylinder made sufficiently large to leave an annular air space one half inch wide between it and the calorimeter.

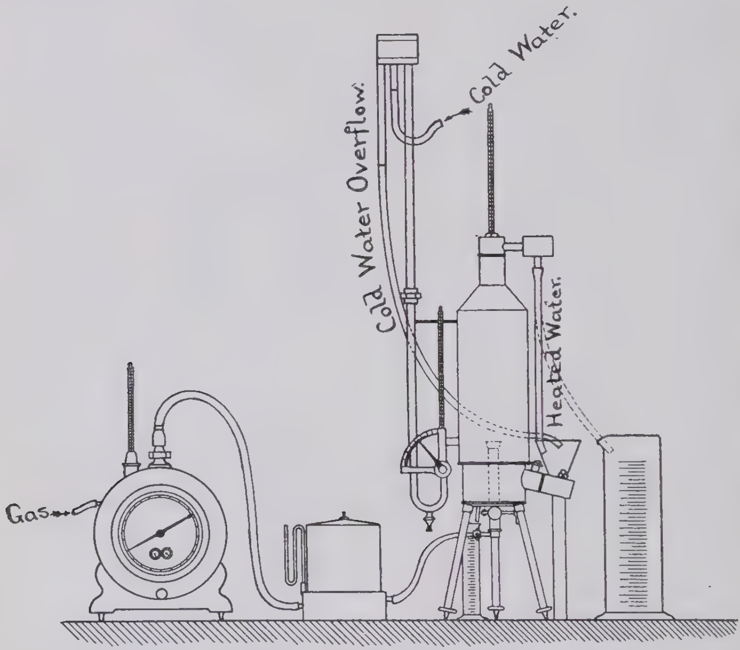
When set up, the apparatus stands on three removable legs provided with leveling screws. Reference to the accompanying sections of the calorimeter will, in connection with the above description, enable the construction of the apparatus to be fully understood.

Two measuring glasses are provided with the calorimeter. The larger one will hold two litres and is graduated in intervals of five cubic centimetres. The other is an ordinary 100 cubic centimetre glass, graduated to one-half of a centimetre. (A litre is 1,000 cubic centimetres and a litre of water weighs one kilogram.)

When it is desired to make a determination of the calorific value of a gas, the apparatus is set up on a firm base in such a position that it can be readily supplied with the gas to be tested and with flowing water. The thermometers provided for the purpose, which are graduated in tenths of degrees Centigrade from 0° to 50°, should be inserted in the proper openings, as described above. Connection is then made to the water supply by means of rubber tubing slipped over the nipple on the bottom of the smaller inside cup, of the two supported by the pipe which enters the calorimeter at the bottom of the upper compartment. A rubber tube leading to a drain is slipped over the nipple opening from the larger cup in the space outside the small one, and another pipe is slipped

on the nipple leading from the funnel in the cup supported by the pipe coming out of the tube at the top of the conical hood.

Water being turned on flows into the small cup and thence down through the pipe around the U bend, up through the stop cock, around the bulb of the thermometer inserted into the tee and into the annular space around the tubes. It rises



Junker's Calorimeter and Auxiliary Apparatus set up ready for Use.

through this space and passes up the central tube, in which it is thoroughly mixed by the baffle rings, over the bulb of the thermometer inserted into the tee at the top of the tube and thence by the side pipe to the cup in which it rises until it overflows into the funnel and passes away by a rubber tube slipped over the funnel nipple. By admitting water into the small cup at a faster rate than that at which it is admitted to

the calorimeter, this cup is filled, and water overflows from it into the larger cup, from which it runs off through the nipple and tube to the drain. In this way a constant head for the supply of water is maintained, and as the water also overflows into the funnel on the outlet at a constant height, the effective head is constant, and the water must flow through at a constant speed as long as the stop cock remains set at any given opening.

The gas to be consumed is led to the apparatus through an experimental meter, by which it is measured, and a sensitive governor, by which the pressure, and consequently the rate of flow for any given opening of the stop cock, is kept constant. For illuminating gas a Bunsen burner is used, and the gas is burned at the rate of five to six cubic feet per hour. After being lighted the burner is placed inside the inner cylinder and clamped to the rod provided for this purpose. The clamp arm is of such a length and the rod is so flattened that when the set screw is tightened the axis of the burner coincides with the axis of the calorimeter, and it is fastened at a height that brings the bottom of the flame five to six inches above the lower edge of the apparatus.

The products of combustion rise inside the inner cylinder until they strike the inner hood, and then pass down through the tubes to the lower annular compartment and out through the outlet flue to the air. In the passage up the inside of the cylinder and through the tubes they impart their heat to the water surrounding the tubes, and emerge from the apparatus at a temperature either exactly or very nearly that of the air. Any water vapor formed by the combustion of the gas is condensed and runs off through the small pipe tapped into the ring closing the bottom of the lower annular compartment.

To make a test, water is started flowing through the apparatus, and the gas burner lighted and put in place, and the flow of gas adjusted to the proper rate. The flow of water is then adjusted by the graduated stop cock to a rate that will give the desired difference in temperature between the outgoing and incoming water. This difference is usually kept between 10° and 20° C. When the temperature of the outgoing water, as shown by the thermometer at the top of

the calorimeter, is at the desired point and remains constant, and the condensed water has begun to drop from the tube at the bottom, a test can be made. The hand of the meter must be watched, and as it passes the zero mark the end of the tube through which the heated water is flowing must be inserted in the large graduated measure and the small measure placed under the condensed water outlet. Four or five observations of the temperature of the water as it enters and leaves the apparatus must be made and recorded at regular intervals. When the meter hand crosses the zero mark after making either one or two revolutions, depending upon the rate at which the water is flowing, the hot water tube must be removed from the measure and the water allowed to run to waste again. The observed temperatures are then averaged, and the difference between the outlet and inlet temperatures obtained. The amount of water collected in the measuring glass is read off in cubic centimetres by means of the scale marked on the glass, and this amount reduced to litres and decimals of a litre by dividing by 1,000 or pointing off three decimal places. Since a calorie is the quantity of heat required to raise the temperature of one kilogram of water 1° C. and a litre of water weighs one kilogram, the product obtained by multiplying the amount of water collected, measured in litres, by the number of Centigrade degrees by which its temperature is raised, is the number of calories absorbed by the water and consequently the number produced by the combustion of the measured quantity of gas. This number can be changed to British thermal units by multiplying it by 3.968, one calorie being equal to that number of British thermal units, and from this figure and the quantity of gas used, the calorific value of the gas in British thermal units per cubic foot can be readily found.

The result so obtained is the gross calorific value of the gas, the water formed having been condensed in the calorimeter, and it is to enable the net calorific value to be determined that this condensed water is collected and measured. The amount can be measured for each test, but since the quantity is comparatively so small that the unavoidable error in reading amounts to a large percentage, it is best to allow one cubic

foot of gas to be burned and use the amount of condensed water collected during the combustion of this quantity of gas as an average to be employed for each of the different tests made at that particular time. Having the amount of condensed water, the latent heat of the steam corresponding to it can be calculated and deducted from the gross heating value to obtain the net heating value of the gas under test. A convenient rule is that for every cubic centimetre of water so condensed per cubic foot of gas burned, a deduction of .6 calorie, or 2.382 British thermal units must be made from the gross calorific value per cubic foot to obtain the net calorific value.

When it is necessary to have very exact results, the temperature of the gases issuing from the calorimeter must be made the same as that of the gas passing through the meter and the water collected should be measured cold. (Trustees.)

10. State two or more conditions making the use of pressure regulators on house piping, or of governor burners of advantage.

Ans. First. A wide variation in the pressure at the meter, such as will be found on feed mains running from the works, or holder stations, to different parts of the district supplied, since to keep up the pressure at far-away points it is necessary, at the times of maximum demand, to carry a much higher pressure on these mains than is required at the times of smaller demand.

Second. A pressure at the burner higher than is consistent with the economical use of gas, such as will be found at the higher points of very hilly districts.

Where these conditions exist, and especially where the one first mentioned is found, it is very difficult to get satisfactory results from gas burners, particularly if they are incandescent burners, without the use of a pressure regulator at the outlet of the meter or of governors on the burners. (Trustees.)

11. If a 4″ gas main will, under certain conditions of length of main, amount of pressure lost by friction and specific gravity of the gas, deliver 1,000 cubic feet of gas per hour,

what amounts of gas will be delivered per hour under the same conditions by a 6″ main and an 8″ main respectively?

Ans. The formula by which the amount of gas flowing through pipes under different conditions can be calculated is

$$Q=1,350 \sqrt{\frac{d^5p}{sl}}$$

in which Q is the number of cubic feet of gas delivered per hour, d is the diameter of the pipe in inches, p is the pressure required for overcoming the friction in the pipe, s is the specific gravity of the gas, and l is the length of pipe in yards. From this formula it will be seen that the amount of gas delivered will, everything else remaining the same, vary as the square root of the fifth power of the diameter of the pipe in inches. The fifth power of 4 is 1,024, and the square root of this is 32, the fifth power of 6 is 7,776, and the square root of this is 88.18, and the fifth power of 8 is 32,768, the square root of which is 181. Therefore, the carrying capacities of 4″, 6″ and 8″ pipes are to each other, all other conditions being the same, as 32 to 88.18 to 181, or as 1 to 2.76 to 5.66. That is, if a 4″ main will, under certain conditions of length, amount of pressure lost by friction and specific gravity of the gas, deliver 1,000 cubic feet of gas per hour, a 6″ main will, under the same conditions, deliver 2,760 cubic feet per hour, and an 8″ main 5,660 cubic feet per hour.

The problem can also be solved with a gas flow computer by setting the figure 4 on the diameter-of-pipe scale opposite the figure 1,000 on the cubic-feet-of-gas-per-hour scale and reading off on this latter scale the figures that stand opposite to 6 and 8 on the diameter-of-pipe scale.

The same relation holds for pipes of any diameter that are to each other in the ratio of 4, 6 and 8, or, what is the same thing, the ratio 2, 3 and 4. Thus, a 12″ pipe will carry 2.76 times and a 16″ pipe 5.66 times as much as an 8″ pipe. (Trustees.)

12. Describe the proper method of preparing and putting in a cement and broken stone concrete for foundations in dry, or nearly dry earth.

Ans. The stone used in making concrete should be clean

and of such a size as to pass in any direction through a 2½ inch ring. The sand should be clean, sharp and coarse. A coarser sand than that used for making mortar for brick work can be employed to advantage for concrete. The proportions of the ingredients depend upon the strength required and upon the average size of the pieces of stone and of the grains of sand used, but, under ordinary conditions, the following proportions make a good concrete:

1 part of Portland cement.
2 parts " sand.
5 " " broken stone.

Broken slag or coarse gravel, if entirely free from loam, may be substituted for the broken stone, and even when the latter is used, one or two parts of gravel may be added to the mixture as given above without decreasing the strength of the concrete.

For mixing the concrete a platform of plank about 10 x 16 feet should be laid. If the cement and sand are to be mixed wet, before being put on the stone, a mortar box should be placed at one end of this platform. Measuring boxes to measure the sand and broken stone should be provided. These are made with four sides only, being open both at the top and bottom. They may be either of one barrel capacity, or the one for the sand may be of two barrel capacity and that for the stone of five barrel capacity, if the mixture is to be as above 1 to 2 to 5, and should be provided with handles so that they can be easily lifted and set to one side after the material has been measured.

The sand and cement should be measured in the mortar box and the stone measured and placed on the platform at the foot of the box in a layer about 6″ to 8″ thick. The sand and cement are mixed in the manner described in the answer to Question No. 12 of the Fourth Series, the stone is wet and the mortar spread in an even layer on top of it. The whole mass is then turned over a sufficient number of times to cause the stone and mortar to be thoroughly mixed together. During this part of the operation care should be taken to really turn the mass instead of merely shoveling it from one place to

another. If properly handled two or three turnings should be sufficient to produce thorough mixture.

Sometimes the cement and sand are mixed and spread on the wet stone in a dry state, the whole mass then being turned over once to mix the stone and cement. Water is then added while the mass is being turned a second time, and the turning continued until the mixture is completed. When this method is followed there is no need of a mortar box, the cement and sand being mixed on the platform.

In either case it is important not to use too much water, since wet concrete cannot be compacted by ramming. The proper quantity of water to be used should be determined by experimenting with the first two or three batches made, and the same amount should thereafter be used for each batch unless the temperature and humidity of the atmosphere change decidedly, in which case the amount of water will have to be varied to suit the changed conditions.

When thoroughly mixed, the concrete should be put in barrows, carried to the excavation, dumped quietly into place and then rammed until the moisture appears on the surface. In no case should it be thrown into place with shovels, or dropped from any height, since the result of such treatment is to separate the stone and mortar and prevent the formation of a solid block of concrete.

In preparing the excavation, the earth at the bottom should not be disturbed, and should it be loosened it must be rammed until firm. Where soft or yielding earth or sand occurs, the bottom should be planked and the concrete laid on this planking. The concrete should be laid in layers of not less than 5″ or more than 9″. When joined to old work, this should be carefully cleaned, wetted and dusted with dry cement. (Trustees.)

Eleventh Series of Questions — Section of 1906 — Practical Class — American Gas Light Association.

1. It is found by test at a certain gas works that when using anthracite coal in the generator of the carburetted

water gas apparatus the generator fuel amounts to 34 lbs. per 1,000 cu. ft. of carburetted gas made and the rate of make is 13,000 cu. ft. per hour, while when a certain furnace coke is used the generator fuel amounts to 37 lbs. per 1,000 cu. ft. and the rate of make is only 9,000 cu. ft. per hour. The price of the coal is $4.90 per gross ton and the wages of the gas maker are 20 cents per hour. What would be the equivalent price per gross ton of the coke, all items affecting the cost of the gas which are not mentioned above being considered equal in the two cases?

2. How would you make a working test of the proportion of volatile matter and coke in any sample of coal?

3. Give a description, illustrated with sketches, of some form of apparatus for concentrating ammoniacal liquor. Describe the process of concentrating the liquor and state the conditions that render it advisable to so treat the liquor.

4. How can the weight of water evaporated per pound of fuel by a boiler under ordinary working conditions be determined approximately?

5. How would you determine the area of the purifying boxes required to purify economically any given amount of gas per twenty-four hours?

6. Give your theory of the causes of stoppages in the standpipes of coal gas retorts and the means you would employ to prevent them.

7. Describe the proper treatment of iron oxide from the time it is taken out of the box for revivification until it is again returned to the box.

8. What is the maximum amount of gas containing 0.60 per cent. by volume of H_2S that can theoretically be purified during continuous exposure by a bushel of purifying material weighing 50 lbs. and containing 64 per cent. by weight of $Fe_2O_3.H_2O$? It is assumed that no oxygen is present in the gas. Give all calculations.

9. How would you proceed to locate an obstruction in the distribution system of your town, the presence of which is indicated by a general complaint of poor supply in a district which is fed from several points and in which the pipes are large enough to properly supply the demand if no obstruction exists?
10. How would you repair a leak resulting from a broken main? Give a full description of the fittings used and the manner in which these fittings should be applied to the main in order to make the repair complete and permanent.
11. What are the conditions leading to efficiency of working in a gas engine?
12. What are the precautions that should be taken in laying fire brick and fire clay blocks to secure for the finished work strength and the ability to resist heat?

(Answers to these questions are due November 1, 1905.)

Answers to Eleventh Series of Questions—Section of 1906—Practical Class—American Gas Light Association.

The answer to question No. 3 is included among the answers to the seventh series of questions for the section of 1907, and can be found on page 85 of this volume.

The answers to the other questions are as follows:

1. It is found by test at a certain gas works that when using anthracite coal in the generator of the carburetted water gas apparatus the generator fuel amounts to 34 pounds per 1,000 cubic feet of carburetted gas made and the rate of make is 13,000 cubic feet per hour; while when a certain furnace coke is used the generator fuel amounts to 37 pounds per 1,000 cubic feet and the rate of make is only 9,000 cubic feet per hour. The price of coal is $4.90 per gross ton and the wages of the gas maker are 20 cents per hour. What would be the equivalent price per gross ton of the coke, all items affecting the cost of the gas which are not mentioned above being considered equal in the two cases?

Ans. Since, as stated in the question, the items of generator fuel and gas maker's labor are the only ones to be considered, the price of coke equivalent to a price of $4.90 per gross ton for anthracite coal must be such that the total cost of gas maker's labor and generator fuel per 1,000 cubic feet of gas made will be the same in each case.

In the case of the coal, under the conditions stated, in the question, 34 pounds costing $\frac{490}{2240} = 0.219$ cent per pound, are required for generator fuel per 1,000 cubic feet of gas made, so the cost of this fuel will be $34 \times 0.219 = 7.45$ cents per 1,000 cubic feet. The cost of gas maker's labor is 20 cents per 13,000 cubic feet or $\frac{20}{13} = 1.54$ cents per 1,000 cubic feet. The total cost for generator fuel and gas maker's labor is therefore 8.99 cents per 1,000 cubic feet.

When using coke the gas maker's labor will cost 20 cents per 9,000 cubic feet, or 2.22 cents per 1,000 cubic feet. The price at which coke must be bought to be equivalent to coal at $4.90 per ton is therefore $8.99—2.22 = 6.77$ cents for the amount, 37 pounds, required as generator fuel per 1,000 cubic feet of gas made. This is equal to a price per pound of $\frac{6.77}{37} = 0.183$ cents, or a price per gross ton of $4.10. (Trustees.)

2. How would you make a working test of the proportion of volatile matter and coke in any sample of coal?

Ans. To make a working test of the amount of volatile matter in any given sample of coal, weigh out enough of the coal to make an average charge for, say, two retorts, and put it into two adjacent retorts, care being taken to secure a fair sample of the coal to be tested and select retorts fully up to the normal heat. Draw the retorts containing the weighed charge at the regular time, and if the coke is well burned out, catch it in a barrow or buggy (the floor in front of the retorts should be swept clean, and all the coke that falls on the floor during the draw be picked up and put in the barrow) and weigh it at once while hot, and before any water is used to quench it.

The difference between the original weight of the coal and the weight of the coke is the weight of the volatile matter driven off during carbonization, and this multiplied by 100

and divided by the weight of the coal, gives the percentage of the volatile matter in the coal. Thus, if 600 pounds is taken and the coke weighs 402 pounds, 600—402 = 198 pounds is the weight of the volatile matter, and $\frac{198 \times 100}{600} = 33$ is the percentage of volatile matter in the coal. In the same way the percentage of coke can be figured. In the case assumed above it is $\frac{402 \times 100}{600} = 67\%$.

If the coal is wet it should be allowed to dry before being weighed for the test, and if, when the retorts are opened, it is found that the gas has not been thoroughly expelled from the charge, the coke should not be weighed, but another lot of coal should be weighed out and another test made.

Tests of this kind are valuable as giving, to a certain extent, a check on the quality of the coal supplied, and should be made either on each shipment, or, if this is not convenient, on every third or fourth shipment received. (Trustees.)

4. How can the weight of water evaporated per pound of fuel by a boiler under ordinary working conditions be determined approximately?

Ans. An approximate determination of the weight of water evaporated per pound of fuel consumed by a boiler, under ordinary working conditions, can be made by measuring the water fed to the boiler during any period of regular operation, and weighing the fuel used during the same period. The water line should be at the same height and the fire in practically the same condition at the end of this period as they were at the beginning.

An easy way of measuring the water fed to the boiler is to put a water meter on the feed water pipe, between the feed pump and the feed water heater, if one is used, so that all the water put into the boiler, and only the water so used passes through the meter. The weight of a cubic foot of the water used at its ordinary temperature having been obtained by drawing off and weighing a sufficient number of samples to get a fair average, the volume of water used, as shown by the meter readings, can then be multiplied by this weight of unit volume to find weight of water used. This total

weight, divided by the weight of fuel consumed, gives the weight of water evaporated per pound of fuel.

If the feed water connection between the meter and the boiler is kept tight and the meter kept correct by periodical testing, this method will give fairly accurate results. It is useful for determining which one of several fuels, purchased at different prices, is really the most economical to use, without going to the expense of making a number of complete tests in which every precaution is taken to insure extreme accuracy. When kept in use continuously, the meter being read every day at a regular time, and approximately the same amount of fuel kept in stock, it is also valuable as a check upon the quality of the work of the fireman. In this way alone it will more than repay the slight cost of the extra meter and connections, and the time required for making the necessary observations and calculations. (Trustees.)

5. How would you determine the area of the purifying boxes required to purify economically any given amount of gas per twenty-four hours?

Ans. As four-box sets of purifiers are, for many good reasons, the most commonly adopted, this answer treats of such sets only.

The proper area to be given purifying boxes in four-box sets, in order that they may purify economically a certain amount of gas, is determined by empirical rules that have been deduced from the results of experience. The rule that is commonly accepted as correct in England is given in the Sixth Edition of Newbigging's Handbook as follows: "Where there is intended to be four purifiers, three always in action, the maximum daily (24 hours) make of gas, expressed in thousands, multiplied by the constant 0.6, will give the superficial area in feet of each purifier." According to this rule there must be provided 60 square feet of area in each box for every 100,000 cubic feet of gas to be purified per twenty-four hours. As it is not stated what purifying material is to be used in the boxes, it is to be presumed that the rule is intended to apply to both lime and oxide of iron.

Since the quantity of sulphuretted hydrogen and other

sulphur compounds in the gas determines the amount of work to be done in the purifiers, and the English gas coals contain more sulphur, on an average, than the American coals, the English rule may very possibly give an area that is larger than it is necessary to have in this country. For although the work done by a bushel of lime, or a bushel of oxide of iron, per change (which in the case of lime is the whole amount of work obtained) increases with an increase in the ratio between the area of the boxes and the amount of gas to be purified per day, and the cost of labor per 1,000 cubic feet (and in the case of lime of material also) is thus reduced, the increase in size carries with it an increase in the fixed charges for interest and depreciation on the cost of the purifiers and of the house in which they are enclosed, which must sooner or later balance the reduction in operating expenses. The most economical area is therefore that which gives the smallest total for the costs for labor and material and the fixed charges.

The trustees are not aware of anything having been published in which the question of the balancing of these two items of cost against each other is treated with regard to purification by lime, so for lime purifiers there are no data from which to determine whether the rule given by Newbigging is correct for American conditions. The cost of labor and material being larger with lime than oxide, lime purifiers must be made larger than oxide purifiers to obtain the most economical results, but with the present knowledge it cannot be said exactly how much larger they should be.

For purification with oxide of iron, the subject of the most economical size of purifiers for use with carburetted water gas has been investigated by Mr. J. A. P. Crisfield, and the results obtained are given in a paper read by him in October, 1903, before the American Gas Light Association, and published in the Proceedings of the Association, Vol. X, page 217, and in the American Gas Light Journal, Vol. L, page 653, and Progressive Age, Vol. XI, page 356. By means of experiments conducted on a working scale, Mr. Crisfield determined the amounts of gas purified, during one exposure, per cubic foot of oxide for different lengths of time taken by the gas to pass through the oxide contained in three boxes of

a four-box set, and also the cost of the labor required to remove the oxide from and replace it in the boxes. From these data the cost of purifying labor per 1,000 cubic feet could be calculated for each length of time that the gas remained in contact with the oxide. The cost of material was not considered, but since with oxide this cost is very small, and is probably not very much affected by the amount of work done per change, it is not important. By combining with the costs of labor the costs of interest and depreciation on the estimated values of the various sized purifiers and purifying houses that would be required to cause gas passing at an assumed rate per hour to stay in contact with the oxide the different lengths of time for which the cost of labor had been obtained, the conclusion was reached that the most economical length of the time of contact was forty-eight seconds. However, in order to provide for the use of oxide of iron less efficient than that used in his experiments, Mr. Crisfield gave the following rule for determining the most economical size of purifying boxes for use with oxide of iron, this rule being based upon a time of contact of sixty seconds. "$60 = \frac{3600V}{3R}$ where V is the volume of oxide" (in cubic feet) "between inlet of first box and point of testing gas and R is the rate" (of make) "per hour. By substitution of the desired rate per hour V becomes known: divide V by 2 or 3, dependent upon whether it is the intention to test on second or third box, and the result is the volume of oxide in one box which may be put into any length, breadth and depth that is convenient.

"The equation may be simplified for convenience to read $R = 20\ V$. Or the volume of oxide between the inlet to the purifiers and the point of treating for sulphuretted hydrogen should be $\frac{1}{20}$ of the rate per hour."

Mr. Crisfield apparently intended that the average rate of make throughout the year should be used in this formula, since it is in this way that it has been used to determine the sizes of the boxes necessary. But if this is done, when the make is at the maximum the time of contact falls below the number of seconds stated by him as the limit below which the oxide ceases to do any work. It would seem therefore as if the maximum rate of make should be used instead of the

average. Assuming the boxes to be worked three on and one off, as is customary, and the oxide to be in a layer 30″ deep in each box, as can easily be accomplished in boxes 4′ deep, even when a catch layer of shavings is used below the layer of oxide, the rule gives the area required in each box as 42 square feet per 100,000 cubic feet of the maximum twenty-four hours make. If the valve arrangement is such as to permit of all four boxes being worked at once, so that the gas can be tested at the outlet of the third box, the area given by this rule is only 28 square feet per 100,000 cubic feet of the maximum twenty-four hours make.

Mr. Crisfield's experiments having been made with carburetted water gas, which contains less sulphuretted hydrogen than does coal gas, the area determined by this rule is too small for coal gas work. A common practice is to make the boxes for coal gas work 33⅓% larger than those for carburetted water gas work, an area (in square feet) equal to the maximum make (in 1,000 cu. ft. per 24 hours) multiplied by 0.3 being taken for the latter, while the area for the former is reached by the use of the factor 0.4.

In designing a new set of purifiers, it is necessary to make a proper allowance for the probable increase in the amount of gas made, and to take as the maximum make to be provided for, not the make at the time, but such an one as circumstances indicate will be reached within a reasonable time. Proper allowance must also be made when it is known that the gas making materials that are to be used contain an unusually large percentage of sulphur. (Trustees.)

6. Give your theory of the causes of stoppages in the standpipes of coal gas retorts and the means you would employ to prevent them.

Ans. The causes commonly accepted as leading to excessive trouble from stoppages in the stand-pipes of coal gas retorts are:

First. The subjection of the gas in the retort and stand-pipe to excessive pressure owing to the dip-pipes being sealed in tar, to the hydraulic main being choked with pitch, to the stand-pipes being too small originally or having been allowed to become partially filled up, or to the existence of obstructions

in other parts of the apparatus which cause pressure to be thrown on the hydraulic main and consequently on the stand-pipe and retort.

Second. Irregularity in working owing to irregularity either in the heat of the retorts or in the weight of coal put into the retorts at successive charges.

Third. High heats and large yield of gas per pound of coal.

Most of these causes are, so to speak, indirect causes leading up to and rendering inevitable the final action in the stand-pipe itself, which, of course, is the direct cause of any stoppage. It seems probable that irregularity in working, which is more apt to occur when high heats are employed to secure the complete carbonization of the coal, since with low heats and yield it is easier to keep the working regular, is the most fruitful of these indirect causes in producing stoppages in stand-pipes. In spite of large stand-pipes, a liquor seal, or even no seal at all, a free flow of gas produced by an exhauster taking all pressure off the hydraulic main, and comparatively low heats, stopped stand-pipes will be frequent and troublesome unless the heats are kept even and the same weight of coal can be, and is, properly carbonized on each charge. On the other hand, high heats and large yields may be the rule, and other bad conditions may exist, but if the working is regular, stopped stand-pipes will be few in number. When we consider the conditions existing in the stand-pipe itself that tend to produce stoppages, the reasons for this great influence of regularity in working, or the reverse, are apparent.

With the retort heats, now usually employed, there is probably always a small amount of free carbon in the form of light particles of soot in the gas as it passes from the retort. A certain amount of condensation also is continually going on in the stand-pipe, the liquid products of which run down the inner side of the pipe walls, becoming thicker and thicker as the lighter constituents are distilled out by the great heat encountered in the lower portions of the pipe. Under these conditions a stoppage may occur in any one of three different ways.

The amount of solid matter may be large enough to cause a dry soot stoppage, which, however, is easily removed, or there

may be a complete though comparatively gradual stopping of the pipe through the conversion of the condensation into successive layers of pitch until the pipe is completely closed, or finally the distillation of the condensation may only proceed to the thick tar stage, and this tar catching the soot forms a thick, pasty, gluey mass, which completely closes the pipe. It is this last form of stoppage that is principally produced by irregular heats and hit or miss charging. When the heats are down or too large a charge is put in, the stand-pipe is well coated with thick tar, and if on the next charge too liberal an allowance is made for the previous error a quantity of soot is produced, to be caught by this tar, with a stoppage as the result.

If this theory as to the cause of stoppages in stand-pipes is true, as seems probable, it will be seen that even under the conditions of even heats and charging of the retorts, properly designed stand-pipes and hydraulic main and the maintenance of a uniform low pressure or even a slight vacuum on the main, there is always a tendency for the stand-pipes to stop, owing to the absorption of the solid particles, always present in the gas, by the liquids condensed from the gas during the cooling that must inevitably occur in its passage up the stand-pipe and the coking of the mixture so produced as its volatile constituents are driven off by the heat of the gas passing through the stand-pipe.

The remedies suggested to overcome this tendency of the stand-pipe to become stopped may be classed under two heads; 1st, Those designed to strain the solid particles out of the gas before it leaves the mouthpiece by the use of gratings, screens of wire cloth, or similar appliances, through the openings in which the gas has to pass before it reaches the stand-pipe, and 2d, Those designed to alter the temperature conditions that exist in the stand-pipe. The second class may be subdivided into appliances having for their object the reduction of the amount of condensation in the stand-pipe by preventing, as far as possible, loss of heat by radiation, and those having for their object the securing of a more rapid condensation through cooling the stand-pipes by artificial means, as well as by cutting off as far as is possible, the heat radiated from the benches.

The remedies belonging to this last subdivision have proved the most successful, the effect of keeping the pipes hot being in almost every case merely the transfer of the trouble to the bridge-pipe, dip-pipe or hydraulic main. In general, they depend on the use of a small jet, or jets of water either playing on the outside of the stand-pipe, which is kept cool by the evaporation taking place, and thus cools the gas more rapidly, or trickling down the inside, in which case the gas is cooled directly. Stand-pipes corrugated so as to increase the amount of radiation by increasing the surface, and stand-pipes made very thin have also been employed.

The reason of the success of these cooling arrangements in preventing stoppages is not clearly understood. In a paper, "Stoppages in Ascension Pipes," read before the American Gas Light Association in 1880 (see Proceedings, Vol. IV, page 232 to 250), Mr. Theobald Forstall stated his belief that they were successful only because they produced "a simultaneous and indirect cooling of the mouthpiece which was in itself sufficient to accomplish the result." He says, "It appears to me probable that, under certain conditions of coal and high retort heats, a series of hydrocarbon vapors may be produced in the early stages of distillation which solidify upon contact with the relatively cool surface of the ascension pipes; and, further, that in order to effectually prevent stoppages from this cause, these vapors must be completely intercepted in the mouthpiece itself. This could be effected by cooling the mouthpiece to that point only which will determine the condensation within it, in a liquid form, of all vapors which solidify on their passage to the hydraulic main; but, at the same time leaving the ascension pipes to retain their normal heat, so as to allow the greater portion of the tar vapor to pass over to the hydraulic main. Perforated diaphragms or gratings in the mouth piece would assist in this condensing process, as well as entrap the soot deposit."

Another explanation of the beneficial effect of cooling the stand-pipes is given by Mr. N. H. Humphrys in an article, "Stoppages in Ascension Pipes" (published in the Journal of Gas Lighting, Vol. LXIX, page 403, and reprinted in the American Gas Light Journal, Vol. LXVI, page 684) from

which the following quotation is taken: "* * * It would appear that a certain quantity of finely divided solid matter is carried forward from the retort to the ascension pipe. Being partly softened by the heat, or charged with tarry matter, it would soon form a ring around the lower part of the ascension. Condensed matters from the upper part, slowly trickling down, and being rendered more and more viscid by the vaporizing of their lighter constituents as they successively reach warmer and warmer surfaces find a lodgment here, and are retained and baked into hard coke or graphite. But supposing the condensation is increased by additional cooling influences. The deposit trickling down the interior of the ascension pipe will then not only be more abundant, but more liquid—sufficiently so not only to reach the mouthpiece itself, but also to carry the solid particles with it. I take it that these choke-preventing devices act by conveying down into the mouthpiece the matters that, under other circumstances, would form chokes. Apparatus for effecting this result has the practical advantage of being cheap, easily applied to existing apparatus without stopping the make of gas, and as easily removed if found to be unsuitable." He also states that the same effect of extra condensation can be produced in many instances by lengthening the stand-pipes. Both of these papers should be read by the student.

In conclusion it may be safely stated that with 6 inch or 7 inch stand-pipes, which are kept clean and free from deposited carbon, even heats and regular charging, a liquor seal of not more than one inch, and an absence of pressure on the hydraulic main, trouble from stopped stand-pipes can be kept at a minimum, and at the same time high heats be employed to secure a large yield per pound, while, if trouble does come, it can be diminished by cooling the mouthpiece and lower portion of the stand-pipe. All of which is subject to the condition that, like naphthalene, stopped stand-pipes at times do not seem to be amenable to any treatment, owing probably to the existence at different times of variations in the conditions which are not discovered nor understood. (Trustees.)

7. Describe the proper treatment of iron oxide from the

time it is taken out of the box for revivification until it is again returned to the box.

Ans. As probably no two samples of iron oxide (the words being used to denote a purifying material in which the active agent is hydrated ferric oxide) are exactly alike, it is impossible to lay down hard and fast rules that will apply in all cases. But there is one truth that must always be borne in mind and acted upon to secure the best results. This is, that revivification will be the more rapid and complete, the higher (within reasonable limits) the temperature of the oxide. Therefore, the treatment should be such as to retain, as far as possible, in the material, all the heat generated by the chemical action that occurs, provided, of course, that this heat is not excessive.

At a works using oxide purchased from three different firms, the following method of handling during revivification was found to give the best results:

As the oxide was removed from the box, it was thrown on to the revivifying floor, beneath the box, in two heaps, each about 8 feet high, and allowed to remain in these heaps until it was thoroughly heated, the length of time required for the attainment of this result varying from one or two hours for fresh, active oxide, to 48 hours or more, for that nearly spent, or sluggish from any other causes. When hot, it was taken from the heaps and placed on the floor, in long ridges, whose cross section was approximately an equilateral triangle with 24 inch side. Spaces were left between the ridges, and as the oxide on the two exposed faces revivified, as shown by its change of color, it was scraped down into these spaces until the whole batch was spread out in a layer, with a uniform depth of about 9 to 10 inches. It was then turned over with shovels, care being taken to have it really *turned* and the material that had been on the bottom placed on top, instead of the whole mass being merely shoveled to one side, which is very often all that the so-called turning over amounts to. By this time it was usually thoroughly revivified. If not, it was again turned over as often as necessary. When revivified, the batch was piled in a heap about 6 feet high and 4 to 6 feet

wide, to remain until it was put back into the box in due course. Sufficient time was allowed to elapse between each handling for complete revivification of the top layer of oxide. During the operation the oxide was never wet, unless it became excessively heated, or so dry that there was a loss and a nuisance in handling, owing to the dust arising from it. By thus keeping the oxide as dry as possible, all the heat produced by chemical action was made available for maintaining the temperature of the material and thus promoting complete revivification, instead of being used up in vaporizing the added water.

In handling batches of fresh oxide care must be taken to prevent their becoming so highly heated as to ignite the sulphur and shavings contained in them. Even in such cases, however, it is better to allow the oxide to stay in heaps, as since less surface is exposed to the air in this way the liability of ignition is less, and if it does occur the fire can be more readily extinguished by the use of water. Such heaps should be examined at frequent intervals and any tendency to fire promptly corrected. Ignition cannot occur with wet oxide until the water has been practically all evaporated, so wetting the oxide will always prevent it. But as it also retards revivification, it should only be resorted to in cases of necessity. Spreading the oxide out in thin layers and turning it constantly will also cool it.

If the batch of oxide does not heat and revivify properly when handled as above, and its record shows that it is not yet saturated with sulphur, it can sometimes be brought into good condition again by being exposed out-of-doors in the sun during the warm weather, the sun imparting the heat necessary to start and maintain the revivification. Or the batch can be heated artificially.

Another method of revivification consists in placing the oxide, when taken from the heaps, on a platform of purifier trays supported about a foot above the floor of the revivifying room in such a way as to permit a free circulation of air underneath the whole bed, the oxide being spread in a layer 24″ to 30″ deep. When using such a platform, revivification takes place on the bottom as well as at the top of the layer,

proceeding faster on the bottom. When the batch is turned, the oxide still foul should be put on the trays, and the oxide that has revivified either piled to one side or placed on top of the foul oxide. If this method is used with active oxide, great care will be necessary to prevent firing, as revivification proceeds very rapidly owing to the fact that air passes up through the oxide instead of merely being in contact with it. (Trustees.)

8. What is the maximum amount of gas containing 0.60 per cent. by volume of H_2S that can theoretically be purified during continuous exposure by a bushel of purifying material weighing 50 pounds and containing 64 per cent. by weight of $Fe_2O_3.H_2O$? It is assumed that no oxygen is present in the gas. Give all calculations.

Ans. Since the purifying material is assumed to weigh 50 pounds per bushel and to contain 64 per cent. by weight of Ferric Hydrate ($Fe_2O_3.H_2O$), each bushel will contain $50 \times 0.64 = 32$ pounds of $Fe_2O_3.H_2O$.

According to the answer to Question No. 6 of the Ninth Series the reactions on which the removal of sulphuretted hydrogen (H_2S) from gas by $Fe_2O_3.H_2O$ chiefly depend are as follows:

$$Fe_2O_3.H_2O + 3H_2S = Fe_2S_3 + 4H_2O$$
$$Fe_2O_3.H_2O + 3H_2S = 2Fe\,S + S + 4H_2O.$$

The proportion between $Fe_2O_3.H_2O$ and H_2S being the same in both of these equations, the amount of H_2S absorbed by a given quantity of $Fe_2O_3.H_2O$ will be the same, no matter what combination of the two reactions actually occurs.

The atomic weight of Iron (Fe) being 56, and that of Oxygen (O) 16, that of Hydrogen (H) 1, and that of Sulphur (S) 32, we have $Fe_2O_3.H_2O = (2 \times 56) + (3 \times 16) + (2 \times 1) + 16 = 178$ and $3H_2S = 3\ (2 \times 1 + 32) = 3 \times 34 = 102$. Therefore 178 parts by weight of $Fe_2O_3.H_2O$ will combine with 102 parts of H_2S or 1 pound will combine with $\frac{102}{178} = 0.573$ pound, and 32 pounds of $Fe_2O_3.H_2O$ will combine with $32 \times 0.573 = 18.336$ pounds of H_2S. But 1 pound of dry H_2S at 60° F. and 30″ barometer occupies a volume

of 11.1229 cubic feet, so 18.336 pounds will correspond to $18.336 \times 11.1229 = 203.95$ cubic feet of H_2S.

As the gas is assumed to contain 0.60 per cent. by volume of H_2S it will contain 6.0 cubic feet of H_2S per 1,000 cubic feet. $\frac{203.95}{6.0} = 33.991$, and therefore 33.991 cubic feet is the maximum amount of gas containing 0.60 per cent. of H_2S that can theoretically be purified during one exposure by a bushel of purifying material weighing 50 pounds and containing 64 per cent. by weight of $Fe_2O_3.H_2O$. Obviously this amount will vary according to the weight of $Fe_2O_3.H_2O$ contained in a bushel of material.

It is also possible by admitting oxygen with the gas, and thus securing a continuous partial revivification, to purify more gas to an exposure than is indicated by the method of calculation given above. Unless oxygen is supplied, however, the duty actually obtained in practice from any material will always be less than the theoretical amount obtained by calculation, as it is impossible, under working conditions, to thoroughly saturate with H_2S all the $Fe_2O_3.H_2O$ in the material. (Trustees.)

9. How would you proceed to locate an obstruction in the distribution system of your town, the presence of which is indicated by a general complaint of poor supply in a district which is fed from several points and in which the pipes are large enough to properly supply the demand if no obstruction exists?

Ans. It is assumed, as a matter of course, that all the drips in the various mains supplying the district have been gone over, as soon as attention is called to the trouble, to make certain that it does not arise from a flooded drip due to an unusual cause that has developed since the time of the last periodical examination, and that they have been found all right.

This possible cause having been eliminated from the problem, the next step is to determine which of the several feed mains, by which the district is supplied, is the one that is obstructed. To do this it is necessary to observe the pressures, at the time of heavy consumption in the district, at a series of points

along each of the mains, using for the purpose lamp post pipes, or special pressure pipes, if either exist, or else the pumping pipes on drips that are suitably located, or as a last resort the consumers' services. If recording gauges are available in sufficient number, they can be used and will give a means of comparing the pressures at the various points during the whole time of heavy consumption; but if they are not available the desired information can be obtained by the use of ordinary syphon gauges in the following manner: Observation must be taken at, at least, two consecutive points simultaneously. The gauge farthest along in the direction in which the work is being done, which should be that in which the gas is expected to flow, is then left in place while the other gauges are moved to the point next in succession and another set of simultaneous observations taken, this process being repeated until the whole length of the pipe has been covered.

When the pressures have to be taken from the services with syphon gauges all the requisite preparatory work should be done in the day time, so that there will be nothing to do in the evening except to attach the gauges and take the observations. The amount of gas being used through each service, at the time the pressure is observed, should be noted, to determine whether any allowance should be made for a reduction in pressure on this account. Any other causes, such as differences in elevation, that would normally affect the pressure, must also be taken into consideration and an allowance made for their effect.

The location of the point at which the pressures are to be taken will depend largely upon the special conditions existing in any system, but, in the absence of any reason to the contrary, they should be selected so that the pressures should, under normal conditions, show as nearly as possible equal drops between consecutive points.

If no obstruction exists in the main being tested the pressure will show a gradual and uniform decrease at each point, and if the observed pressures decrease in this way the pipe is thus shown to be free from obstruction. An obstruction, by causing the flow of gas through the pipe to be below the normal amount, will cause the pressure to show practically no

reduction up to the place at which the obstruction is located, with a sharp drop, equal to almost the whole loss, as soon as the obstruction is passed. When these conditions are observed on one of the mains it is certain, not only that the obstruction that is being sought for is in this main, but also that it is located between the two points showing the large difference in pressure. The exact location can then be found by taking the pressures at various points between those determined as above, the points being taken closer and closer together until the drop in pressure is located between the two consecutive available points that are nearest to each other. When this has been done, the main must be uncovered at a point midway between those at which the pressures were last taken, a hole tapped in the pipe and the pressure taken to determine on which side of this hole the obstruction is to be sought. A stout wire can then be inserted, in the proper direction, to determine whether the obstruction is within striking distance, and if so, its exact location and nature. If it cannot be located in this way the main must be uncovered at another point, midway between the last point and that one of the points previously taken which shows the marked difference in pressure, a hole tapped, the pressure taken and the wire used, this being repeated until the exact location of the obstruction is found.

The above method, which requires that the taking of pressures be done during the time of maximum consumption, that is usually in the early evening, is the only one that can be employed when the day consumption is comparatively small. When the day consumption is relatively large, the line in which the obstruction exists can be determined in the day time by bagging off the feed mains, one after another, at points as far removed from the centre of the district as possible, noting, in each case, the pressure at some point in the district, both before and after the bag is put in. If a main is doing its share of the work of supplying the district, stopping it off will cause an appreciable reduction in the pressure, while if it is already obstructed the effect of a complete shutting off will not be marked. If, therefore, the pressure shows no decided change when one of the mains is bagged the obstruction is to

be sought in that main, and its position can be located by bagging at several points in succession and noting in each case the drop in pressure on each side of the bag when gas is allowed to escape from the pipe through the bag hole, the bag being put first to one side of the hole and then to the other. As long as the obstruction has not been passed the flow of gas induced in this way will cause only a slight drop on the side towards the feed, and a larger one on the side towards the district. As soon as the pipe is bagged on the district side of the obstruction the drop in pressure will be almost the same on both sides and the obstruction must be looked for between the first hole at which this is observed and the last hole at which normal conditions were found to exist. This method of bagging the mains is especially useful where no services are taken off the feed mains for some distance before the affected district is reached.

The character of the steps to be taken to remove the obstruction will depend upon its nature. If it is an accumulation of water due to a sag in the main, all that is required is the regrading of the main, while if it is a solid obstruction that cannot be removed by the use of solvents, it may be necessary to cut the main before it can be cleared. (Trustees.)

10. How would yon repair a leak resulting from a broken main? Give a full description of the fittings used and the manner in which these fittings should be applied to the main in order to make the repair complete and permanent.

Ans. The main having been uncovered and the break located, the escape of the gas should be stopped temporarily, by pressing either clay or soap into the crack. The further procedure depends upon whether the break runs around the pipe so as to be all included within not over four or five inches in length, or extends longitudinally for a greater distance than this. In the first case the repair can be made with a split sleeve; in the second, the cracked piece must be cut out and a new piece inserted.

When a split sleeve is to be used, all dirt and rust must be scraped off the pipe for a distance of a foot on each side of the break, and if the pipe has settled it must be brought back to the proper grade and alignment. A strip of unbleached

muslin, wide enough to cover the break with a margin of three or four inches on each side and long enough to wind completely around the pipe several times, is smeared with a putty made of white lead, or equal parts of white and red lead, and linseed oil and wrapped tightly around the pipe over the break. This serves to entirely prevent the escape of gas while the job is being completed. A split sleeve, that is a sleeve made in two pieces, each of them similar in size and shape to the pieces that would be obtained by splitting a solid sleeve along a plane containing both its axis and a diameter and provided with longitudinal flanges by which they can be bolted together, is then applied so as to cover the pipe at the break and for at least three or four inches on each side of it. The joint between the split sleeve and the pipe can be satisfactorily made in various ways.

One method is to plaster the inside of each half of the sleeve with a layer of Portland cement, mixed neat, of sufficient thickness to insure the complete filling of the joint and the compacting of the cement without allowing the flanges to come face to face when the two parts are put over the pipe and drawn together by means of the bolts. Enough cement should squeeze out through the spaces between the flanges to fill them thoroughly, but if this does not occur any unfilled places can be pointed up, so that, when the job is completed and the cement has set, the two halves of the sleeves are joined together with a gas tight joint by the cement between the flanges.

Another method is to make the joints between the flanges gas tight by using strips of millboard that have been soaked in hot water until they have become soft enough to be squeezed into all the roughnesses of the faces of the flanges when the two halves of the sleeves are put in place, surrounding the pipe, and bolted together. The joint between the sleeve and the pipe is then made exactly as would be done in the case of a solid sleeve, using either lead or cement. The latter is preferable, unless the conditions are very much against its use, since making lead joints involves the carrying to every repair job of a furnace, lead pot and ladle. Drawings of two styles of split sleeves, showing their dimensions and the number of

bolts used, can be found in the Proceedings of the American Gas Light Association, Vol. XV, page 88, and on page XIV of the appendix, and also in the American Gas Light Journal, Vol. LXIX, page 712, and Progressive Age, Vol. XVI. page 529.

When the break runs too far along the pipe to be properly covered by a split sleeve it is necessary to cut out the damaged portion of the pipe, making the cuts at least three or four inches beyond the furthest point reached by the crack at each end, and replace it by a new piece. To do this the main must be uncovered for a sufficient distance to enable bag holes of the proper size to be drilled and tapped far enough apart not to interfere with the work of putting in the new piece. The gas having been shut off, by means of the bags inserted in these holes, the pipe is cut at the proper points, either with a pipe cutter or by the use of diamond points and cold chisels, and a new piece of pipe of the required length cut and put in, a solid sleeve being used to make the joint where the two spigot ends come together. Before sliding the sleeve into place, the opening between the two spigot ends is covered by wrapping the pipe with unbleached muslin prepared and used as is done in connection with the repair by means of a split sleeve. Either lead or cement joints can be made in the bell and in the sleeve, but the use of cement is generally preferable for the reasons stated above. (Trustees.)

11. What are the conditions leading to efficiency of working in a gas engine?

Ans. The essential conditions for efficiency in a gas engine are:

1. The largest volume of cylinder with the smallest circumferential surface; in other words, the largest diameter of cylinder.

2. Maximum speed of piston.

3. Greatest possible expansion.

4. Highest possible pressure at the beginning of the explosion.

These conditions were first laid down by Beau de Rochas in 1862. They all tend to insure the least possible loss of heat from the cooling effect of the walls of the cylinder and through

the exhaust, and consequently tend to secure the greatest possible utilization of the heat produced by the combustion of the gas and therefore the greatest possible efficiency of the gas engine. (Trustees.)

12. What are the precautions that should be taken in laying fire bricks and fire clay blocks to secure for the finished work strength and ability to resist heat?

Ans. The principal precautions to be taken in laying up fire bricks or fire clay blocks are that the bricks, or blocks, should be well wetted just before they are laid in place, and that each brick, or block, should be rubbed into place in such a way as to bring its faces almost into contact with the faces of the adjacent bricks, or blocks, in the wall, the joints being made as thin as it is possible to have them, and at the same time have the fire clay fill all the interstices, so as to give a uniform bearing over the whole surface. This is especially important in the case of arches, which should be laid as nearly as possible with the blocks face to face. Bricks and small blocks can be wet by dipping them into water in a bucket, kept filled and at hand for the purpose, each piece being dipped by the mason as he picks it up for the purpose of laying it in place in the wall. The surfaces of large blocks should be wet by having water sprinkled on them, a convenient method being to employ for the sprinkling a whisk broom which is wet by being dipped into the water in the bucket. The portion of the work previously laid, upon which the bricks, or blocks, are to be placed, should also be wet in the same way.

To secure thinness of joints, those surfaces of the blocks which come together should be smooth plane surfaces, being dressed to this condition if they do not originally possess it, and the fire clay must be mixed thin rather than stiff, care being taken not to get it so thin that it will run out of the joint, nor so stiff that any excess will not be squeezed out when the block is worked into place. If the joints are not made thin, the fire clay will soften and run out of them when the work is subjected to heat, or even if it does not do this it

will shrink under the action of the heat and cause a settlement of the upper part of the brick work.

Another precaution which should be observed is that when it is necessary to cut bricks or blocks, the cut surfaces should never be exposed to the direct heat of the fire, the face so exposed being always one which has not been cut. (Trustees.)

Fourth Series of Questions—Section of 1908—Practical Class—American Gas Light Association.

1. What conditions, other than the size, would determine your choice in selecting one of several kinds of anthracite coal offered for use as the generator fuel in a carburetted water gas apparatus?

2. How do you determine when the checker brick in a carburetted water gas apparatus needs cleaning?

3. Give a description, illustrated with sketches, of one or more forms of the condensers used for cooling illuminating gas during the process of manufacture.

4. Why is it important that all tar and oily matter should be removed from the gas before it enters the scrubbers and purifiers?

5. A two lift gas holder, the upper section of which is 140 feet in diameter, gives a pressure of 3.2 inches when uncupped, and one of 4.8 inches when cupped. What is the weight of each of the sections? Give your calculations.

6. A gas with a specific gravity of .630 is supplied to a building 57 feet high. The gas is at rest for the time. The pressure at the ground level, as shown by a syphon gauge, is 1.5 inches. What will be the pressure shown by a guage attached to the riser pipe at the top of the building. Give your calculations.

7. In the answer to Question No. 7 of the Third Series the yield of ammoniacal liquor per net ton of coal is given

as 27 gallons of from 8 to 10 ounce strength. How many pounds of pure ammonia gas, NH_3, does this amount of liquor represent?

8. Give a description—illustrated with a sketch of a longitudinal section of both spigot and hub showing outside diameter of spigot, all dimensions of the hub or bell, the shape of the lead groove in the bell, and the depth and finished shape of the lead—of the making of a lead joint in a 4 inch cast iron main. Give also the amount of lead and packing used and the length of time that should be required to do the work.

9. What is a Holophane globe and how does it affect the useful light given by the source of light over which it is used?

10. In setting a gas range which has an oven burner and four top burners, what size of pipe should be used, and to what size meters should it be connected? Give the reasons for your answer.

11. Give a description, illustrated with sketches, of two or more methods of connecting services to street mains, and state what you consider to be the respective advantages and disadvantages of each method.

12. Describe the preparation and use of cement mortar for brick work construction, with the precautions to be observed to insure strength and uniformity.

(Answers to these questions are due December 1, 1905.

Answers to Fourth Series of Questions—Section of 1908—Practical Class—American Gas Light Association.

1. What conditions, other than the size, would determine your choice in selecting one of several kinds of anthracite coal offered for use as the generator fuel in a carburetted water gas apparatus?

Answer. The object in selecting an anthracite coal for use as the generator fuel in a carburetted water gas apparatus is to obtain the coal that will produce the most gas at the smallest cost. The price being equal, the cost of the gas is affected by the quantity of gas that can be made from a given weight of fuel, the amount of sulphur compounds in the gas, the rate at which the gas can be made and the amount of labor required to handle the apparatus. The quantity of gas that can be made depends largely upon the amount of fixed carbon in the coal and also upon the hardness and ability to withstand handling, and the weight of the fuel above it in the generator, without breaking up into small pieces. The amount of sulphur compounds in the gas depends, of course, upon the amount of sulphur in the coal, other things being equal. The rate at which the gas can be made is influenced by the ability of the coal to resist crushing, without which the fire cannot be kept in good condition for gas making as well as by the amount and character of the ash through its influence upon the nature and quantity of the clinker formed. The latter also determines the amount of labor required for cleaning the fire, while the cost of labor for gas making proper depends upon the rate at which the gas is made.

The best coal for the purpose named is therefore the one that contains the largest percentage of fixed carbon and is hard enough not to break up into small pieces in the generator, or while being handled before being put into the generator, and shows only small percentages of sulphur and of an ash that produces a clinker that does not unduly obstruct the passage of the blast and steam through the fire, nor make the cleaning of the fire difficult. To fulfill this condition, the ash should not contain much sulphur or iron. Since a red color is due to the presence of iron, the white ash coals give the least trouble from clinker.

It is, however, difficult to secure a coal that possesses all of the above qualities in the highest degree, and also entirely possible to pay too much for them. Therefore, in making a choice between different kinds of coal it is always necessary to balance advantages in one direction against disadvantages in another and so determine carefully the relative values of the

different samples, selecting the one that is shown in this way to be the cheapest at its price. (Trustees.)

2. How do you determine when the checker bricks in a carburetted water gas apparatus need cleaning?

Ans. The checker bricks of a carburetted water gas apparatus should be removed and cleaned, or renewed when dirty or crushed, or disintegrated. Checker bricks may become covered with a non-conducting coating of ashes or carbon, or both, making impossible the desired exposure of the oil vapors to properly heated brick surfaces. When bricks are coated or saturated with carbon the surface heats rapidly, because the carbon burns, and the gas maker is deceived by the glowing carbon and believes the bricks to be hotter than they are. It is possible to tell something of the condition of the checker bricks by observation through the sight cocks provided for the purpose. Other indications of dirty bricks are a falling off in the rate of make per minute and in the oil results. If all the conditions of operating remain unchanged, and the candle power falls materially and stays down and the make of gas per minute of run is reduced, the checker bricks should be at once examined and, if dirty, cleaned and removed. Bricks should not be allowed to become so fouled as to make a material reduction in the rate of make. Experience soon teaches an intelligent gas maker to avoid both the extreme of reduced results and of too frequent cleaning.

It is the custom in many works, especially those that are provided with a spare set of apparatus, to change the checker brick at regular intervals, these intervals being measured in some cases by the number of days that the set has been in operation, and in others by the number of hours of work actually done. The object of changing the bricks at fixed intervals in this way is to avoid the irregularities in make and working results that arise from running until it is absolutely necessary to make the change, it being thought the loss due to a day or two of poor working is greater than the slight extra cost involved in cleaning the bricks a little oftener.

In a works that has only one set of apparatus, the bricks should be put in good shape as late as possible in the fall so

that they will be in good condition during the heavy make of December and January. (Trustees.)

3. Give a description, illustrated with sketches, of one or more forms of the condensers used for cooling illuminating gas during the process of manufacture.

Ans. One of the earliest and simplest forms of condensers used for cooling illuminating gas during the process of manufacture is composed of ordinary cast iron pipes inclined at a small angle to the horizontal and fastened to the side of a wall in such a way that the pipes zigzag back and forth until the ground line is reached. The gas passes through these pipes and radiates its heat into the air until it is cooled down to the temperature of the atmosphere. This form has been elaborated into what is known as the flat screw condenser, in which the inclined pipes are in double tiers and are mounted on frames or standards.

Another simple form of atmospheric condenser is composed of vertical pipes mounted on a cast iron box. The pipes are connected together at the top, in pairs, by return bends provided with cleaning holes, and in the box, partitions sealed in the liquids condensed from the gas, are placed between the pipes joined together by the bends, there being one partition for each pair of pipes. The box is thus divided into compartments into each of which two pipes, which are not connected together at the top, open. At each end is a single pipe opening into a compartment of the box, into which also opens one pipe of a set of two connected at the top. By this arrangement the gas entering at the top of the single pipe at one end passes down into the box and then up and down the pipes alternately until it passes out at the top of the single pipe at the other end of the apparatus.

This condenser has also been elaborated from the simple form containing only a single row of pipes into a condenser containing several parallel rows, the top connection between the pipes being made by properly placed hoods sealed in liquor, the box and partitions at the bottom being substantially the same as in the simple form.

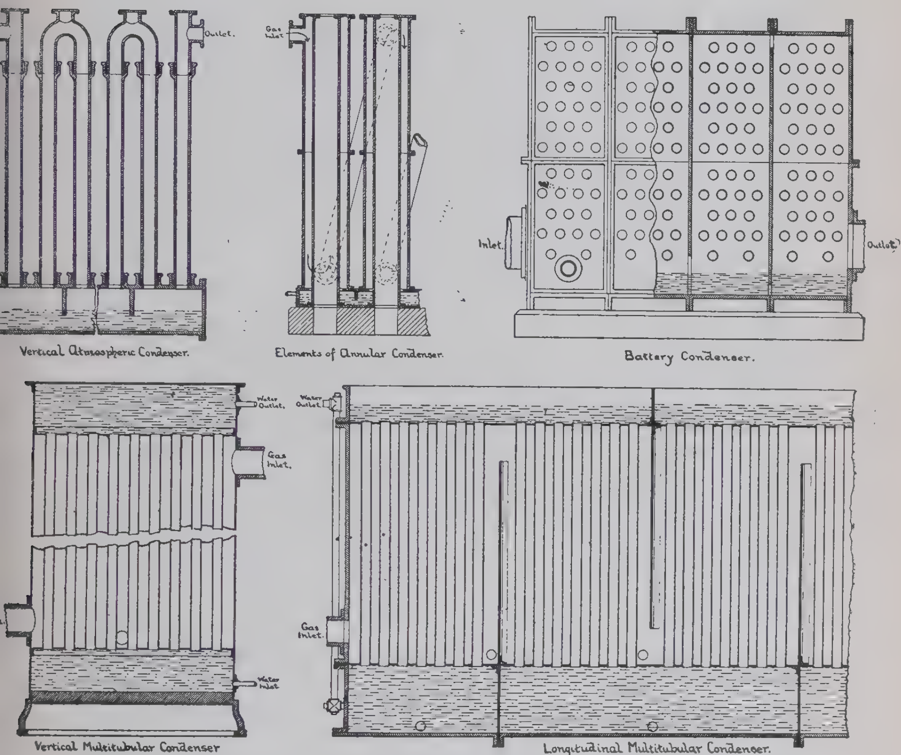
Another vertical atmospheric condenser is the annular

condenser, which consists of a series of large pipes, through the centre of each of which passes a smaller pipe, open to the air at both top and bottom. The gas travels through the annular space between the pipes and imparts its heat to a current of air induced through the centre as well as on the outside of the pipe, the radiating surface being thus nearly doubled. The annular space in one pipe is connected to that of the next by a smaller outside pipe, or pipes, which conveys the gas from the top of one space to the bottom of the next, or vice versa, or else this space is divided into two parts by vertical ribs extending almost the whole length of the pipes, so that the gas passes up on one side and down on the other, and the spaces are connected by short pipes running from the bottom of one to the bottom of the next. If the ribs are arranged to make the gas travel first down and then up, the spaces are connected together at the top instead of the bottom.

Still another form of atmospheric condenser is that known as the battery condenser. This is an oblong box from 2′ to 5′ wide, 10′ to 18′ high and of varying length. It is divided internally into compartments by means of partitions leaving openings alternately at the top and bottom, so that the gas entering at the bottom of the first compartment is forced to travel up in this and down in the next until it passes out at the bottom of the last compartment. Tubes 2″ in diameter, with both ends open to the air, are run horizontally across the compartments, and the currents of air passing through these tubes assist in cooling the gas. In both the annular and the battery condensers arrangements are made for regulating, in one case the size, and in the other the number, of the openings for the admission of air, in accordance with the temperature of the air and gas at different times.

Atmospheric condensers of one or another of these types are practically the only condensers used in England, but in this country it is considered better practice to employ condensers in which the cooling of the gas is effected by imparting its heat to water. The usual form of such condensers is the ordinary vertical multitubular type. This consists of a cylindrical wrought iron or steel shell from 2′ to 8′ or 10′ in diameter, and from 12′ to 20′ high, closed at the bottom by a

cast iron base plate and at the top by a plate of the same material as the shell. It is divided into one gas and two water compartments, by two horizontal tube sheets one placed from 18″ to 30″ from the top and the other the same distance from the bottom. In these sheets are expanded a number of tubes,



Condensers.

which run through the large gas compartment and open into the smaller water compartments at the top and bottom. Water under pressure being run into the bottom compartment rises through the tubes to the top compartment, from which it overflows. The hot gas is admitted at the top of the gas compartment and passes down around the tubes and out at the bottom, becoming cooled as it descends. In this way the

hot gas comes in contact first with the part of the tubes containing hot water, and then, as it descends, with the parts containing cooler and cooler water, so that the cooling of the gas should take place gradually. It is found, however, that it is a very difficult matter to regulate the water supply in this form of condenser, so as to both cool the gas thoroughly and at the same time prevent the cooling from taking place suddenly in a space extending over not more than one-quarter to one-third the total height of the condenser.

Sometimes in works making over 500,000 cubic feet per day there is used a rectangular, multitubular condenser made not more than 12′ high, 5′ wide, and of a length proportioned to the amount of gas to be handled. The shell of this condenser is made of cast iron plates, and the long gas compartment is divided by vertical transverse partitions with openings alternately at the top and bottom, so that the gas traveling through it passes alternately up and down. The water compartments are also divided by similar partitions so placed in each compartment that the water travels up the tubes which pass through the spaces in which the course of the gas is downwards, and down the tubes passing through the spaces in which the course of the gas is upwards. The cold water is admitted at the end at which the gas passes out, and the hot water passes out at the end at which the gas enters, gas and water thus traveling always in opposite directions. With such a condenser properly proportioned to the amount of gas to be handled, the cooling of the gas can be effected very gradually and the difference in temperature of the gas and water at any given point need not exceed 5° Fahr., and by care can be kept still lower. The first cost of the apparatus is, however, greater than that of vertical condensers rated at the same capacity.

Both of these forms of multibular condensers are also modified by making the gas pass through the tubes, which are then surrounded by the water.

All of the types of condensers described must, of course, be furnished with suitable overflow connections for the condensed liquids, and every condenser should be equipped with two thermometers for ascertaining the temperature of the gas, one at the inlet and one at the outlet, in addition to which

water condensers should also be provided with thermometers for determining the temperature of the water as it enters and leaves the apparatus.

In English practice, with atmospheric condensers, 10 square feet of surface, including all exposed pipes from the hydraulic main to the outlet of the condensers, are allowed for each 1,000 cubic feet of gas made per twenty-four hours. In this country it is usual to allow in water tube condensers 5 square feet of tube surface for each 1,000 cubic feet of gas made per twenty-four hours, but if it is desired to cool the gas very gradually and not to have more than 5° difference between the temperature of the gas and that of the water at any given point in the condenser it is necessary to allow from 8 to 10 square feet of tube surface. (Trustees.)

4. Why is it important that all tar and oily matter should be removed from the gas before it enters the scrubbers and purifiers?

Ans. If the tar and oily matter are not removed from the gas before it enters the scrubbers in a coal gas works, they will coat the material in these vessels with a greasy film that will prevent the water from being spread out and presented to the gas, in thin sheets covering the whole surface of the material, and will thus render the contact between water and gas imperfect, with a consequent reduction in the efficiency of the apparatus. If the scrubbers are filled with coke, the deposition of the tar will also fill up the pores of the coke and the spaces between the different lumps and by thus closing up the channels through which the gas has to pass, will cause the scrubbers to throw a high pressure and make it necessary to remove the coke much oftener than would otherwise be the case, increasing in this way, quite considerably, the cost of material and handling.

The presence of tar and oily matter in the gas produces a similar effect in the purifiers. The friction to which the gas is subjected in passing through the purifying material causes the tar and oil to be deposited, coating the different particles of the material with a film that prevents any contact between them and the gas, and thus renders them incapable of doing any

of the work of purification. If either tar or oil is present in sufficient quantity, its deposition makes the material at the bottom of the first purifier moist and soggy, and when in this state it is very difficult for the gas to pass through it, so that it is often necessary to change the purifiers before they are foul on account of excessive pressure. This further increases the cost of labor in addition to the increase in cost of both labor and material caused by the material being rendered inefficient. In the case of iron oxide the oily film on the particles prevents revivification as well as purification, the material lying next to the bottom trays being made unfit for further use, the effect extending to a greater or less distance from the bottom, according to the amount of tar and oil in the gas.

In addition to the main effects noted above, the coating of the scrubbing and purifying materials with a film of tar and oil, also causes intimate contact between tar and gas, and thus reduces the candle power of the gas to a slight extent. (Trustees.)

5. A two-lift gas holder, the upper section of which is 140 feet in diameter, gives a pressure of 3.2 inches when uncupped, and one of 4.8 inches when cupped. What is the weight of each of the sections? Give your calculations.

Ans. The pressure thrown by a gas holder, as measured in inches of water by a syphon gauge, is the height, in inches, of the column of water that is balanced by the weight of the holder. As the pressure acts on each unit of area of the holder crown, the weight of the holder is equal to the product obtained by multiplying the area of its crown by the weight of a column of water, having a height equal to the pressure thrown by the holder and an area equal to the unit used in expressing the area of the crown. Each inch of pressure will represent a weight of 5.208 pounds per square foot, or 0.036 pound per square inch, since a cubic foot of water weighs 62.5 and therefore a column of water one square foot in area and one inch high will weigh $\frac{62.5}{12} = 5.208$ pounds, and a column of water one square inch in area and one inch high will weigh $\frac{62.5}{1728} = 0.036$ pound.

In the example given, the holder has a diameter of 140 feet.

The area of a circle being equal to the square of its diameter multiplied by 0.7854, the area of the crown is 140′ × 140′ × 0.7854=15393.84 square feet. The pressure thrown when the holder is uncupped, that is, when the upper or inner section alone is working, is 3.2″. The weight of this section is therefore 15393.84 × 5.208 × 3.2 = 15393.84 × 16.666=256,553 pounds.

In the same way the weight of the two sections together is equal to 15393.84 × 5.208 × 4.8=15393.84 × 24.998=384,815 pounds.

The weight of the outer section will be 384,815—256,553= 128,262 pounds.

In the Handbooks for Gas Engineers, tables are given showing the weights in pounds corresponding to each $\frac{1}{10}''$ of pressure thrown by gas holders of different diameters from 20 feet to 200 feet. The weight of any given holder can be obtained by multiplying the number found opposite the diameter of the holder in these tables by the pressure thrown expressed in tenths of an inch. The figure given in the table for a holder 140 feet in diameter is 8,018 and this multiplied by 32 and 48, gives 256,576 pounds and 384,864 pounds as the respective weights of the upper section above and of both sections combined. The difference between the weights obtained by the two methods is probably due to a greater number of decimal places having been used in making the calculations by which the tabular numbers are obtained than were used in the calculations given in the first part of this answer. (Trustees.)

6. A gas with a specific gravity of .630 is supplied to a building 57 feet high. The gas is at rest for the time. The pressure at the ground level, as shown by a syphon gauge, is 1.5 inches. What will be the pressure shown by a gauge attached to the riser pipe at the top of the building? Give your calculations.

Ans. From the answer to question No. 6 of the Third Series we find that the amount of the difference in gauge pressure between the upper and lower ends of a vertical gas pipe can be obtained by dividing the difference between the weight of a column of air with an area of one square inch and

a height equal to the difference in elevation between the two ends of the pipe and that of a column of gas of the same area and height by the weight of a cubic inch of water.

In this case the difference in elevation between the ends of the pipe is 57′ and the specific gravity is given as .63. A column of air one square inch in area and 57′ high will contain $57 \times 12 \times 1 = 684$ cubic inches, and, since the weight of a cubic inch of air is .00004418 pound, the weight of this column will be $684 \times .00004418 = .0302$ pound. Since the gas has a specific gravity of .63, the weight of a column of gas will be .63 times the weight of the column of air, and the difference between the weight of the column of air and that of the gas will be .37 times the weight of the column of air.

This difference will therefore be $.0302 \times .37 = .011174$ pound. The weight of a cubic inch of water is .036 pound, and the increase in pressure will be $.011174 \div .036 = .31''$, and the pressure at the top of the pipe will be equal to the pressure at the bottom plus this difference, or to $1.5 + .3 = 1.8''$. (Trustees.)

7. In answer to Question No. 7 of the third Series, the yield of ammoniacal liquor per net ton of coal is given at 27 gallons of from 8 to 10 ounce strength. How many pounds of pure ammonia gas, NH_3, does this amount of liquor represent?

Ans. Since the term ounce as used in designating the strength of ammoniacal liquor means that a gallon of the liquor contains for each ounce strength the quantity of pure ammonia that will neutralize one ounce of pure monohydrated sulphuric acid (H_2SO_4) with a specific gravity of 1.84, each gallon of 8 to 10 ounce liquor will contain an amount of ammonia that will neutralize 8 to 10 ounces of sulphuric acid.

The reaction between ammonia (NH_3) and sulphuric acid (H_2SO_4) takes place according to the following equation, $2NH_3 + H_2SO_4 = (NH_4)_2SO_4$. The proportions by weight in which substances combine with each other can be determined from the molecular weights shown by the equation to enter into the reaction according to which the combination

takes place. As the atomic weight of Nitrogen (N) is 14, that of Hydrogen (H) 1, that of Sulphur (S) 32 and that of Oxygen (O) 16, the proportion by weight in which ammonia and sulphuric acid combine will be $2(14 + 3) = 34$ parts of ammonia and $(2 \times 1) + 32 + (16 \times 4) = 2 + 32 + 64 = 98$ parts of sulphuric acid. One ounce of the latter will therefore combine with $\frac{34}{98} = 0.3469$ ounce of the former, and ammoniacal liquor will contain 0.3469 ounce of ammonia per gallon for each ounce of its strength. Or in other words, the number of ounces of ammonia contained in a given number of gallons of ammoniacal liquor of a given strength is equal to the continued product of the number of gallons, the strength in ounces and 0.3469.

27 gallons of 8 ounce liquor will therefore contain $27 \times 8 \times 0.3469 = 216 \times 0.3469 = 74.93$ ounces or 4.68 pounds of ammonia, while 27 gallons of 10 ounce liquor will contain $27 \times 10 \times 0.3469 = 270 \times 0.3469 = 93.66$ ounces or 5.85 pounds. (Trustees.)

8. Give a description—illustrated with a sketch of a longitudinal section of both spigot and hub showing outside diameter of spigot, all dimensions of the hub or bell, the shape of the lead groove in the bell, and the depth and finished shape of the lead—the making of a lead joint in a 4 inch cast iron main. Give also the amount of lead and packing used and the length of time that should be required to do the work.

Ans. In making a lead joint in a 4″ cast iron main, the first step in the operation, after the spigot end of one length has been inserted in the bell of the other and the length driven home, lined up and fixed in place by the tamping of a little dirt around the middle of it, is to fill solidly with packing, a portion of the joint space between the spigot and bell, the amount of space so filled being determined by the depth of lead which it is desired to have. For ordinary straight work with 4″ pipe the depth of lead may be taken at 1½″, and the joint space will therefore be filled with packing to a point 1½″ back from the face of the bell.

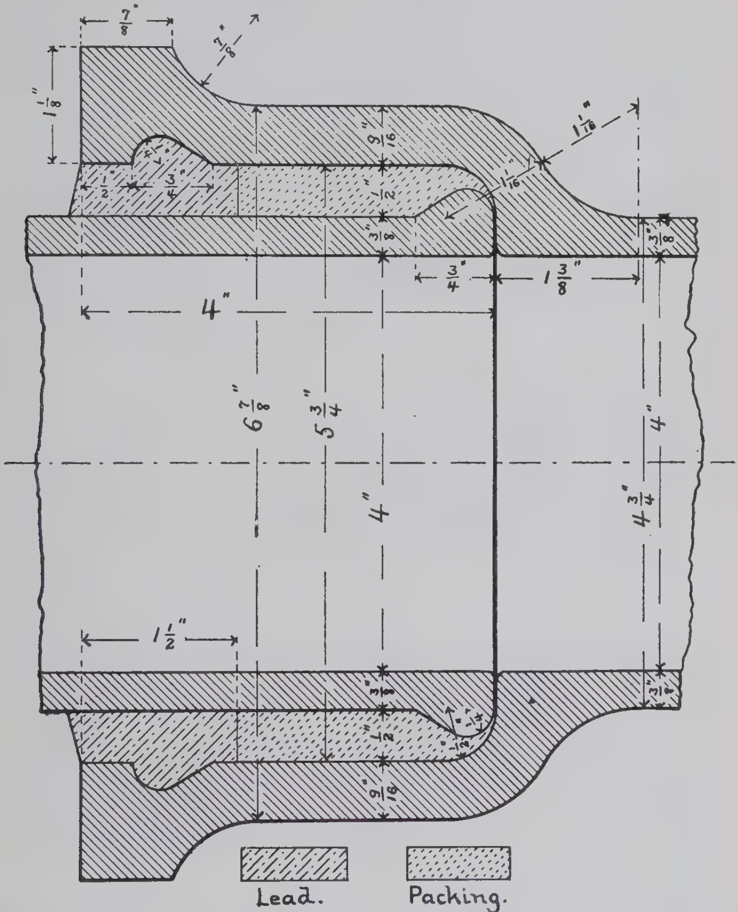
Jute packing, either plain or tarred, is usually employed.

Packing which has been allowed to absorb a small quantity of tar can be driven tighter than plain packing; but, tar being cheaper than jute, it is hard to obtain tarred packing without more than the proper amount of tar, and for this reason plain packing is often given the preference.

A sufficient number of strands of packing should be twisted to form a rope of a diameter a trifle larger than the width of the joint space, and this should be cut into pieces of such length that the ends will come into close contact when a piece is placed around the outside of the spigot end of the pipe and pulled up tight. One of these pieces is used to lift the spigot end as it is inserted into the bell of the pipe previously laid, and is sent home with it, thus keeping the spigot central in the bell and avoiding the necessity of wedging it up after it is in place. This piece of packing is driven solidly into place in the bottom of the joint space by means of a caulking hammer and packing iron, and other pieces are inserted one at a time, the joint in each ring being put, say, one-fourth of the circumference away from the joint in the preceding ring, and each driven home, a sufficient number being used to fill the joint space to the required depth, leaving 1½" for the lead. The packing must be driven hard, and the finished layer must be of uniform depth, so that the lead space will be uniform all around the pipe.

A clay roll or other form of joint runner is then placed around the spigot end of the pipe, being brought tight against the face of the bell, and so set as to leave a triangular space having its base on the pipe and its apex on the face of the bell slightly above the inside edge, which the lead can fill and thus make it certain that, when driven, the joint will be of the shape shown on the cut. Molten lead is run into the joint and this space until both are completely filled and the lead stands above the highest point on the inside edge of the bell, the lead being poured in through an opening, or "gate" left on top of the pipe. When the lead has hardened, the joint runner is removed and the "gate" or lump of lead where the opening for pouring was made is cut off. The lead is then chiseled all around the pipe with a cold chisel and caulking hammer. This separates the lead from the surface of the pipe

and makes a groove in which the first caulking tool, the face of which is about $\frac{3}{16}''$ thick, can fit. The lead is driven all around with this tool and then with tools successively increas-



Section of 4 in. Bell, Spigot and Lead Joint.

American Gas Light Associciation Standard.

NOTE—Cut shows standard in use at time answer was prepared.

ing in thickness about ⅛" until the full width of the joint has been reached. The work with each tool should be begun at

the bottom of the pipe and carried around each way finishing up at the top. The thickness of the last tool used should not be greater than the width of the joint, and the driving with this tool should cut the lead off sharp with the inside edge of the bell, otherwise there is danger that the force of the blows will be expended against the face of the bell instead of doing the full amount of work that it should do in compressing the lead in the joint. In order to have the tools fit the joints exactly, it is well to have them made in sizes varying in thickness $\frac{1}{16}''$, though it is only necessary to use on any joint tools varying by $\frac{1}{8}''$, the proper sizes being selected. The position in which the tools are naturally held when caulking the joint will give it the finished shape shown on the cut, if the joint runner has been put on properly and sufficient lead is used.

There will be required for making a 4″ lead joint about 4 to 5 pounds of lead, and 7 to 9 oz. of jute packing, unavoidable waste being included in each case. A good workman should be able to average nearly 5 joints an hour for a day's work.

The cut shows the spigot and bell of the standard dimensions adopted by the American Gas Light Association in 1898. (Trustees.)

9. What is a Holophane globe and how does it affect the useful light given by the source of light over which it is used?

Ans. The Holophane globe is a globe which diffuses the light from a light source enclosed by it in such a way as to make the whole surface of the globe appear luminous and at the same time changes the distribution of light in vertical planes and throws a larger proportion of the total light in the direction which will prove the most useful for any particular case.

The diffusion of the light is effected by the combination of vertical corrugations on the interior of the globe, the effect of which is to spread the light horizontally, with horizontal prismatic mouldings on the exterior surface which spread the light vertically. The shapes of both the corrugations and the mouldings are carefully designed to secure the transmission of the largest possible percentage of the light through the glass,

and the prisms forming the mouldings are also designed to refract as much as possible of the light in a definite direction.

Thus one form of globe, used for lighting a desk or table by means of lights on a chandelier above it, is so made as to direct the larger proportion of the light downwards; another, used for the general illumination of rooms by means of lights on the chandeliers, distributes the light uniformly in the hemisphere below the horizontal plane passing through the light source, while still another form, used for street lighting, causes most of the light to be given off in the space between this horizontal plane and the cone generated by the revolution of a line drawn through the light source at an angle of 45° with the plane.

Each style requires special forms for the prisms on the exterior surface, and it is also necessary that the forms of these prisms on any one globe vary with their position relative to the source of light, since the rays of light cannot be refracted in parallel directions by prisms of the same shape, when one receives horizontal rays and the other rays at an angle of, say, 45° with the horizontal.

The use of Holophane globes is especially advisable with incandescent gas lights for two reasons. In the first place the intensity of the light is too great to permit of its being used unshaded for ordinary interior lighting. The diffusion effected by the Holophane globe overcomes this objection with the least possible loss of light, since, owing to their design, these globes absorb very little more light than is absorbed by plain glass, while an opal or tinted globe sufficiently dense to cut off the direct view of the light source will absorb a large proportion of the total light emitted by the source. In the second place, the light emitted by a naked incandescent light is, owing to the shape of the mantle, given out principally in a horizontal direction, and so is not available, when, as is usually the case, the light is above the surface to be illuminated. By changing the direction of the rays, the Holophane globe actually increases the amount of light made useful in cases of this kind, the absorption of the glass being more than counterbalanced by the extra rays drawn aside from the illumination of space where only a slight illumination is

needed, and made to take a more useful direction. The total spherical illumination, that is, the illumination of the whole space surrounding the light, is of course diminished by an amount equal to the light absorbed by the globe, the increase in the amount of light at the points where it is to be used being obtained at the expense of the amount at the points where it is not needed. (Trustees.)

10. In setting a gas range which has an oven burner and four top burners, what size of pipe should be used, and to what size meter should it be connected? Give the reasons for your answer.

Ans. A gas range having four top burners and an oven burner should be connected to the meter by ¾″ pipe, if the range is not more than 50′ to 60′ from the meter, and by a 1″ pipe if the distance is greater than this. The meter should not be smaller than 5 light.

A gas range of this description will consume, when all the burners are in use and burning full, at least 60 cubic feet of gas per hour. On a length of 50′, the passage of gas at this rate through ½″ pipe would result in a loss of pressure of from $\frac{4}{10}$″ to $\frac{7}{10}$″, according to the specific gravity of the gas, the limits taken for the specific gravity being .400 and .700. Even the smaller loss is too large, and therefore ¾″ pipe must be used. On a run of 60′, ¾″ pipe will, at the above rate of consumption, cause a loss of pressure of $\frac{2}{10}$″, with gas having a specific gravity of .700, so for runs longer than this 1″ pipe should be used, since, unless the pressure in the street mains is high, it is not advisable to lose even $\frac{2}{10}$″ pressure in the piping.

According to a table given in a paper entitled "The Measurement of Gas," read in 1897, by Mr. C. W. Hinman, before the New England Association of Gas Engineers, and published in the American Gas Light Journal, Vol. LXVI, page 401, a 3-light meter passing 60 cubic feet of mixed coal and water gas per hour, causes a loss of pressure of .37″. Mr. Hinman does not consider this loss too large, and concludes that a 3-light meter is large enough to supply a gas range if this is its sole duty. But a loss of this amount of pressure added to the loss suffered in the piping would, in most

localities, make the pressure at the gas orifices of the range burners so low that it would be impossible to obtain a good atmospheric flame, and in practice it has been found best to use 5-light meters with a range of this description, even when the meter supplies nothing but the range. It is even more necessary that nothing smaller than this size should be used when the meter has to supply the gas for lighting the house as well as that needed for the range. In fact, if the range is a large one, consuming, say, 80 to 100 cubic feet per hour, when all the burners are in use, a 10-light meter will be required to satisfactorily supply gas for both the range and the house lighting. (Trustees.)

11. Give a description, illustrated with sketches, of two or more methods of connecting services to street mains, and state what you consider to be the respective advantages and disadvantages of each method.

Ans. Figure 1 shows the swing joint connection, and is the method now most widely used. It is the joint between the street tee and the street ell that gives the connection its name and enables the direction of the service pipe to be changed at will during laying, without throwing any strain on the main. This flexibility of service line is especially valuable in congested city streets, where a service has at times but a contracted passage, over some obstructions and under others; or where, for any reason, two parts of a service are joined by a long screw. Not only does the swing joint enable the laying of a service without any strain being left on the main, but also, should at any future time pressure bear down on the service, the joint would be of use in either wholly or in great part taking up the strain.

There are a few engineers who believe that where, as in most large cities, a service seldom rests on undisturbed earth, it is safer to block the pipe at each socket, on both sides of the cock, and also close to the main. Of course, this blocking at the main prevents the swing joint from being of use to take up strains coming on the service after it is laid, but the advocates of the blocking believe that a blocked service cannot be pressed down to such an extent as to bring a severe strain on the main,

and they desire the blocking under the service at the main, in order to prevent any strain that may come in the direction of the length of the main, due to the fact that the line of the service is offset from the tap hole by the distance from centre of tée to centre of ell.

The use of the tee instead of an ell enables the flow of gas to be stopped while the service is being laid (a tapered rubber plug being made for this purpose), and in case of any stoppage in a service requiring digging at the main, the access to the service through the top of the tee may obviate any necessity for cutting the service.

The only objection that can be advanced against this form of connection is the greater liability to stoppages as compared with the stiff top connection shown in Figure 2 and the straight side connection show in Figure 3, Figure 1 having one more bend than Figure 2, and two more than Figure 3. This objection has no force applied to the large present-day services and the well purified gas now being sent out, as the cause of the stoppages found in service bends is almost invariably due to rust and sulphur compounds bridging over the comparatively small bore of a ½″ or ¾″ pipe. Even naphthalene need not be considered, for it never appears in this country at the junction of main and service.

Figure 2 shows the rigid form of top connection and many thousands of services have been laid in this manner. As has just been said in talking of the swing joint connection, the advantages of simplicity possessed by Figure 2 over Figure 1 are outweighed by the disadvantage of the rigidity of connection, a rigidity which has been the cause of many breaks in 2″, 3″ and 4″ mains.

Figure 3, the straight connection into the side of the main, is the oldest of all forms of connection and was formerly used to a large extent. It allows a wire to be passed through the service into the main itself, quite an advantage when service stoppages were frequent. At present, this advantage of a straight line from house to main is of small importance, while aside from the rigid connection to the main possessed in common by Figure 3 with Figure 2, the growing congestion of city streets makes a side tapped hole more and more an

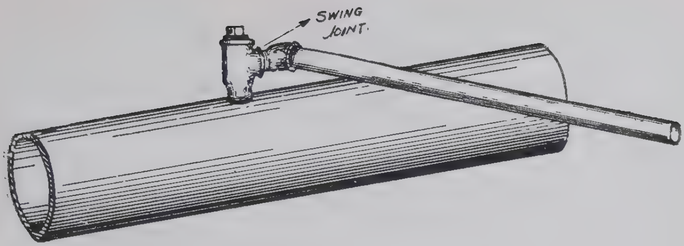


FIG. 1.

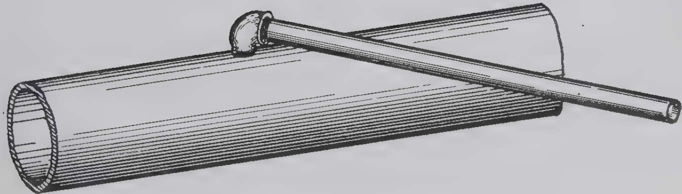


FIG. 2.

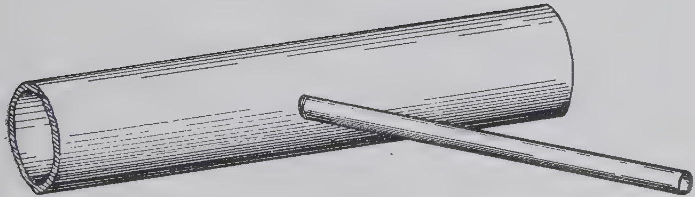


FIG. 3.

impossibility, because of lack of room to work either a tapping machine or a chisel in a horizontal position. (Trustees.)

12. Describe the preparation and use of cement mortar for brick work construction, with the precautions to be observed to insure strength and uniformity.

Ans. A paste of good hydraulic cement hardens simultaneously and uniformly throughout the mass, and its strength is impaired by an addition of sand. The relative quantities of sand and cement depend somewhat upon the kind of work and upon the condition of the ingredients when measured. For ordinary use, it is customary to add as much sand as is possible without making the mortar porous. The proportions may vary from one part of cement and two parts of sand to one part of the former and four of the latter.

The proportions of sand and cement are generally measured by volumes. In actual work the cement is usually divided in barrels, and consequently the most convenient unit for the cement is a commercial barrel, while it is most convenient to measure sand loose.

When the mortar is required in small quantities, as for use in ordinary masonry, it is mixed about as follows: about half the sand to be used in a batch of mortar is spread evenly over the bed of the mortar-box; and then the dry cement is spread evenly over the sand; and finally the remainder of the sand is spread on top. The sand and cement are then mixed with a hoe, or by turning and re-turning with a shovel. It is very important that the sand and cement be thoroughly mixed.

The dry mixture is then shoveled to one end of the box, and water is poured into the other end. An excess of water is better than a deficiency, particularly when a very energetic cement is used, as the capacity of this substance for solidifying water is great. The sand and cement are then drawn down with a hoe, small quantities at a time, and mixed with the water until enough has been added to make a good stiff mortar. This should be vigorously worked with a hoe for several minutes, to insure a good mixture. The mortar should then leave the hoe clean when drawn out of it, and very little should stick to the steel.

Hydraulic cements set better and attain a greater strength under water than in the open air; in the latter, owing to the evaporation of the water, the mortar is liable to dry instead of setting. This difference is very marked in hot dry weather. If cement mortar is to be exposed to the air, it should be shielded from the direct rays of the sun, and kept moist by sprinkling or otherwise.

Grout is a thin or liquid mortar of lime or cement. The interior of a wall is sometimes laid up dry, and the grout, which is poured on top of the wall, is expected to find its way downwards and fill up all voids, thus making a solid mass of the wall.

Grout should never be used when it can be avoided. If made thin, the water only slowly dries out of the wall; and if made thick, the grout fills only the upper portion of the wall. To get the greatest strength, the mortar should have only enough water to make a stiff paste—the less water the better. If the mortar is stiff, the brick or stone should be dampened before laying; else the brick will absorb the water from the mortar before it can set, and thus destroy the adhesion of the mortar.—*Baker's Treatise on Masonry Construction.*

Eighth Series of Questions—Section of 1907—Practical Class—American Gas Light Association.

1. In making coal gas, what influence has the relation between the volume of the charge of coal and the volume of the retort upon the quality of the gas produced from the coal?

2. Describe the operation of a bench of coal gas retorts heated by a regenerative bench, either half depth or full depth, including the care and operation of the furnace, stand-pipes and hydraulic main.

3. Give a description, illustrated by sketches, of the construction and operation of one or more forms of governor for regulating the speed of a coal gas exhauster so as to maintain a uniform pressure, or vacuum, on the hydraulic main.

4. What points are to be provided for in designing the stand-pipes, bridge-pipes and dip-pipes for a bench of coal gas retorts?

5. How much heat is required to change a pound of water at a temperature of 110° F. into steam at a gauge pressure of 80 lbs.?

6. How would you prepare lime for use in purifying gas?

7. What is the influence of heat upon the chemical reactions that occur in the purifiers, and what bearing does this influence have upon the question of the heating of purifying houses, lime rooms and revivifying rooms?

8. A cylindrical oil tank, placed with its axis horizontal, is 4′ 6″ in diameter and 24′ 0″ long. How would you determine the amount of oil it holds for every inch in depth of the oil from 1″ to 54″?

9. A calorimeter test made on a certain illuminating gas gave the following data: Gas consumed, 0.12 cubic feet; average temperature of water entering the calorimeter, 2.5°C.; average temperature of water leaving the calorimeter, 15.2° C.; quantity of water collected, 1509 c. c. (cubic centimetres); quantity of condensed water, 27 c.c. per cubic foot of gas; temperature of gas at meter, 46.5° F.; height of barometer, 29.33″. Calculate both the gross and net calorific value of the gas.

10. It is desired to deliver 8,900 cubic feet of gas per hour through a pipe one mile long with a loss of pressure of 0.4″. The specific gravity of the gas is 0.58. What size pipe will be required? Give your calculations.

11. Give a description, illustrated by sketches, of some form of instantaneous gas water-heater.

12. State some of the reasons for the increasing use of Portland cement concrete in the place of brick or stone masonry.

(Answers to these questions are due January 1, 1906.)

Answers to Eighth Series of Questions—Section of 1907—Practical Class—American Gas Light Association.

1. In making coal gas what influence has the relation between the volume of the charge of coal and the volume of the retort upon the quality of the gas produced from the coal?

Answer. The relation between the volume of the charge of coal and the volume of the retort, or as it is sometimes expressed, the relation between the area of the cross section of the charge and that of the cross section of the retort, has a very decided influence upon the quality of the gas produced and also upon the amount of trouble experienced from stoppages in the stand-pipes and thickening of the tar in the hydraulic main. The quality of the gas is at its best, other things being equal, and the least trouble is experienced, when the volume of the charge is such as to almost completely fill the retort.

The reason for this can readily be seen when the effects produced upon the coal and gas by the exposure to heat to which they are subjected are considered. When the charge is first put into the retort the temperature of the coal and of the portion of the surface of the retort covered by the coal, is low, and the products of distillation are hydrocarbons of high boiling points, that exist as vapors at the temperature in the retort, but condense to liquids when cooled to atmospheric temperatures. As the charge becomes heated, however, hydrocarbons of lower boiling points are giving off, which will remain in the state of gas or vapor at atmospheric temperatures. The interior surface of the retort has by this time again reached its original high temperature, and as the hydrocarbons evolved from the coal pass, on their way to the stand-pipe, through the space left above the charge, they are exposed both to contact with this hot surface and to the heat radiated from it. The effect of this exposure is to break up the more complex hydrocarbons and form hydrogen, simpler hydrocarbons and free carbon, and, given a temperature sufficiently high and an exposure of sufficient length, the final result would be the formation of a gas consisting of hydrogen and marsh gas with no higher hydrocarbons, and the setting free of a large amount of carbon.

Such a gas would be non-luminous, so that, although a certain amount of this breaking up of the higher hydrocarbons after they are evolved from the coal is required to produce a permanent gas, especially at the beginning of the distillation, it is important that the operation should not be carried too far.

The length of time during which the gas will be exposed to this heat depends upon the velocity with which it travels, and this velocity in turn depends upon the area of the part of the cross section of the retort that is not taken up by the charge and upon the rate at which gas is being made. An increase in the volume of the charge for a given size of retort will therefore increase the velocity with which the gas passes to the standpipes, first, by reducing the area of the space through which it passes, and, second, by increasing the rate at which the gas is made, the combined result being that the gas remains exposed to the action of the heated surface of the retort for a much shorter time, and is therefore much less affected by this exposure.

It is true that, although the gas is less exposed to radiant heat when the space is small and the velocity great, a larger percentage of it is brought into actual contact with the surface of the retort, owing to the increase in the ratio between the perimeter and the area of a polygon that occurs when the area is reduced, and that it is also exposed to contact with a greater amount of heated surface as it escapes from the interior of the charge. But experience shows that the combined effect of the radiant heat and the contact with the heated surface in the space above the charge is less harmful when the space is small, and contact with the heated portion of the charge does not have as much effect as contact with the surface of the retort, since during the period in which the greatest amount of gas is given off the temperature of the charge is much lower than that of the retort walls, as, during the first two hours, the temperature of the charge does not exceed 1200° F., while that of the interior surface of the roof of the retort is, in regenerative benches, about 2000° F.

It is therefore important that the size of the retort should be so chosen that the charge which can be carbonized in the desired length of time with the heat to be carried, will fill

the retort as full as it is possible to have it, and still leave room for the operation of the drawing and charging tools. (Trustees.)

2. Describe the operation of a bench of coal gas retorts heated by a regenerative furnace, either half depth or full depth, including the care and operation of the furnace, stand-pipes, and hydraulic main.

Ans. The first point to be noted in operating a regenerative bench is the regulation of the draft. The chimney dampers should be pushed in until, on opening the charging door of the furnace and throwing into the fire a handful of coal dust, the resulting flame plays lazily back and forth out of the door, neither being drawn steadily in by the draft, nor burning up vigorously. The dampers set, the heat is regulated by increasing or decreasing the primary air opening, the secondary air being kept properly proportioned to the amount of carbonic oxide produced by the furnace. The chimney dampers will need readjustment if the quantity of fuel consumed varies materially.

The proper amount of secondary air opening is determined by noting the disappearance in the take-off flue, or at any convenient point of observation in the waste gas flues of the recuperators, where the heat is not too high, of the blue flame that indicates the escape of unconsumed carbonic oxide from the combustion chamber. If this flame is present, the secondary air opening is gradually increased until the flame disappears, waiting a sufficient length of time after each slight increase of opening for the additional air to travel through the bench. When the flame is gone the adjustment is right, and the secondary air slides should be clamped. If no flame is present and the adjustment has not been made for some time, the secondary air openings are decreased until the flame appears, and then the adjustment made as above. The quantity of carbonic oxide produced varying with the condition of the fire as to the amount of ashes, depth of fuel bed, etc., the secondary air supply can not be kept exactly right for every hour of the day; and, this being so, enough is supplied to consume the average maximum production of carbonic oxide,

since the loss of heat due to the small excess of secondary air present when less carbonic oxide is made, is smaller than would be suffered by allowing an equal quantity of carbonic oxide to escape unconsumed; the loss of sensible heat being practically equal in both cases, while with the unconsumed carbonic oxide there is the additional loss of its heat-producing power.

After this adjustment of the damper and air slides is made, they are to be fastened so securely that it is impossible for them to be moved unintentionally.

It is necessary for the proper working of a generator furnace that the fuel-bed be kept deep, and the depth be uniform throughout the furnace.

In cleaning the fire, there should be no work done from the top of the furnace, allowing a rush of cold air through the bench. All the work is done through the cleaning door with a good bed of fuel left in the furnace to heat the excess of inflowing air. Secondary bars, resting on supports provided for the purpose, are driven in above the clinker line to hold up the fire; the grate bars are drawn, dropping the ashes into the pan; any hard clinker on the walls is cut away with chisel bars, the grate bars are replaced and the secondary bars withdrawn, thus letting the fire down upon the grate again.

After taking out the ashes dropped into the pan during the cleaning of the fire, the dirt that has worked into the primary air openings should be raked out.

Every six weeks or two months, the recuperator flues should be cleaned of the deposit of flue dust, as this interferes with the free transmission of heat through the walls to the secondary air. The primary air flues also need regular attention, the bursts of steam caused by the dropping of hot ashes and clinker into the water in the ash pan, when the fire is cleaned, carrying fine dust back into these flues beyond reach from the furnace.

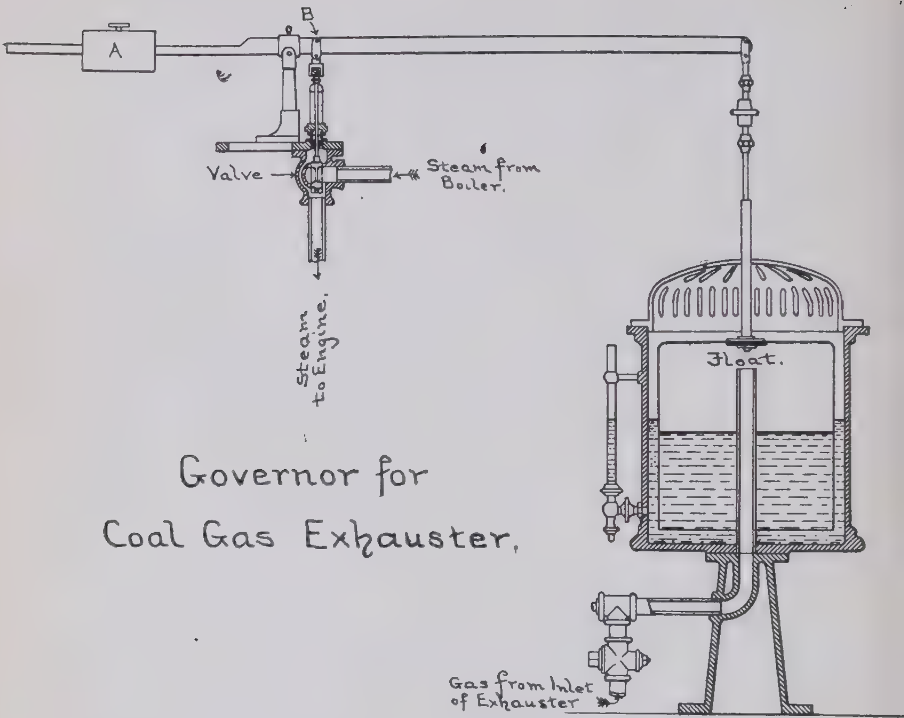
Passing now to the care of the stand-pipes, these should be kept clean. The portion near the mouthpiece should be thoroughly cleaned each time the retort is drawn, and if choked so that the auger cannot be forced up at this time, should be augered after the charge has been in about an hour,

when the obstruction will have been softened. The whole pipe should be cleaned every time the retort is scurfed, so as to allow the passage of a test ring ¼" less in diameter than the pipe. The same course should be followed if the pipe stops up from any cause, the retort never being put back into action until a ring as above will pass down the full length of the pipe.

Unless means for removing the tar as it forms are provided, it should be run off from the hydraulic main at least twice in every twenty-four hours, and more often in case the main is small, to avoid any possibility of the dip-pipes being sealed in tar. In case the tar becomes too thick to run through the take-off, it must be cleaned out through the cleaning holes with which the main should be provided. While running the tar off, care must be taken to maintain the seal of the dip-pipes. Ordinarily the seal is maintained by the liquor condensed from the gas, and a suitable overflow must be provided at the right height to carry off this liquor. (Trustees.)

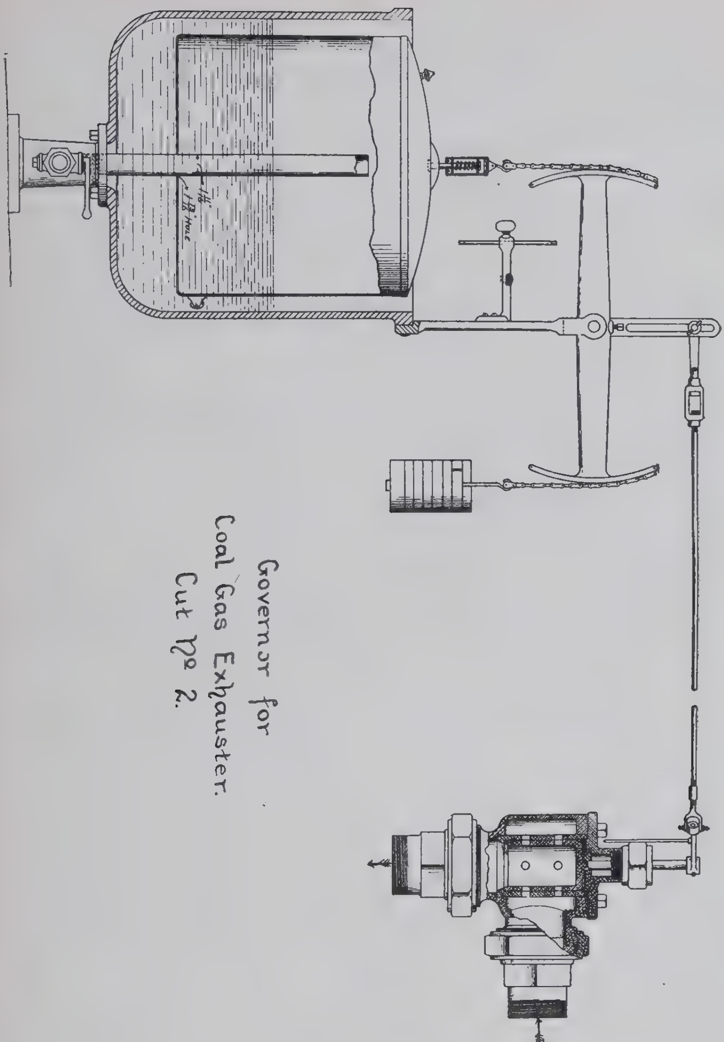
3. Give a description, illustrated by sketches, of the construction and operation of one or more forms of governor for regulating the speed of a coal gas exhauster so as to maintain a uniform pressure, or vacuum, on the hydraulic main.

Ans. One form of such governor is shown in the cut. The inlet of the exhauster is connected by a pipe, as shown, with the interior of a small holder or float, which is free to rise or fall in a vessel of water. This float is connected to a lever as shown, and is balanced by a weight A on the end of the lever. At point B, attachment is made to a valve on the steam pipe from the boiler to the engine, the whole being so arranged that as the float rises the valve is opened, admitting more steam to the engine, and as the float falls, the valve is closed, reducing the amount of steam fed to the engine. If the make of gas increases, the pressure in the apparatus between the retort and the exhauster is increased, the pressure in the float is increased, and it rises, opening the steam valve and increasing the speed of the engine. The speed of the exhauster is thus increased, and the pressure at the inlet of the exhauster reduced to normal.



On cut No. 2 is shown another form of exhauster governor embodying exactly the same principles in a slightly different form of apparatus. In this case a rotary, instead of a lifting valve is used to regulate the amount of steam admitted to the engine and the up and down motion of the bell is transmitted to the valve, and changed into a horizontal rotary motion by means of a rocker arm and system of levers as shown on the cut. Otherwise the action of the governor is exactly the same as that of the one described above.

In order to obtain with these governors the close regulation of the vacuum, maintaining it between limits only two or three tenths of an inch of water apart, it is necessary that everything about them shall work freely and that there shall be no binding at any point. All bearings and places where there is



Governor for Coal Gas Exhauster. Cut No 2.

any movement of one surface upon another must be kept well lubricated and must not be allowed to become gummed up. It is also necessary to restrict the rapidity of motion of the bell so that it will not move so rapidly as to carry beyond the desired point and thus keep the vacuum oscillating violently

back and forth and so defeat its own object. This is done in the governor first described by having the stop cock on the pipe connecting the interior of the bell with the inlet to the exhauster open only a very small amount, so that gas can pass in or out at only a slow rate as the bell rises or falls. Small V-shaped grooves, filed one on each side of the hole through the plug of the stop cock, give openings with which the best results are obtained, the plug being set in such a position that the grooves alone come opposite the openings in the barrel, the main opening in the plug being entirely shut off except for the grooves. In the governor shown on cut No. 2 the same result is sought by making the bell with a closed bottom, as shown, and having the opening in this bottom, through which the pressure pipe passes into the bell, only a very little larger than the pipe. As the bell rises or falls, the water driven out, or drawn in, can pass through this opening only very slowly, and consequently the bell can move at a slow speed only. (Trustees.)

4. What points are to be provided for in designing the stand-pipes, bridge-pipes and dip-pipes for a bench of coal gas retorts?

Ans. The most important thing to be provided for in designing the stand-pipes, bridge-pipes and dip-pipes for a bench of coal gas retorts is, that they shall be made so that every point in each of them can be reached with a cleaning tool having a diameter not more than ½″ smaller than that of the pipe. To enable this to be done, the bent pipes must be made with very gradual curves and without any abrupt changes of direction, and the dip-pipes should be made perfectly straight from the cleaning opening on top to the lower end dipping under the water in the hydraulic main. If abrupt curves are used, it will be impossible to keep the pipes clear and free from stoppages.

It is also well to keep the number of joints down to a minimum, as the breaks in the surface at joints afford an opportunity for the building up of obstructions.

If the above points are observed, the necessity of having the pipes of large diameter is not as great as it is sometimes

thought to be, pipes 7″ in diameter being amply large for retorts carbonizing 350 pounds of coal in four hours.

It is understood to be a matter of course that the pipes will be provided with flanged joints, to enable them to be easily removed and replaced when necessary, and with proper cleaning openings; while the question of whether cast iron or wrought iron is to be used for the stand-pipes is such an open one that it will not be taken up here. (Trustees.)

5. How much heat is required to change a pound of water at a temperature of 110° F. into steam at a gauge pressure of 80 pounds?

Ans. The amount of heat required to change a pound of water at a temperature of 110° F. into steam at a gauge pressure of 80 pounds is equal to the total amount of heat in a pound of steam at 80 pounds pressure less the amount of heat in a pound of water at a temperature of 110° F. The total amount of heat required to raise the temperature of a pound of water from 32° to that of the boiling point at any pressure and then convert it into saturated steam can be determined from the formula $H = 1081.4 + 0.305t$, in which H is the number of B. t. u. (British thermal units) required and t is the common temperature of the water and steam in degrees Fahrenheit. The temperature corresponding to any given pressure can be calculated from the formula $t = \frac{2938.16}{6.1993544 - \log p} - 371.85$, in which p is the absolute pressure in pounds per square inch and t is the temperature in degrees Fahrenheit.

In the problem set in the question the gauge pressure at which the steam is formed being 80 pounds, the absolute pressure is 94.7 pounds and $t = \frac{2938.16}{6.1993544 - \log 94.7} - 371.85 = \frac{2938.16}{6.1993544 - 1.976350} - 371.85 = \frac{2938.16}{4.2230044} - 371.85 = 695.75 - 371.85 = 324.9°$ F. Substituting this value in the formula for the total heat, we have $H = 1081.4 + 0.305 \times 324.9 = 1081.4 + 99.09 = 1180.49$ B. t. u.

The amount of heat required to raise the temperature of a pound of water from 32° F. to 110° F. can, unless extreme accuracy is necessary, be taken as being equal to 78 B. t. u., that is, one B. t. u. for each degree difference in temperature.

The heat required to convert a pound of water at a temperature of 110° F. into steam at a gauge pressure of 80 pounds will therefore be 1180.49 — 78 = 1102.49 B. t. u.

Tables have been made out giving the quantity of heat in a pound of steam for absolute pressures from 0.5 to 400 pounds per square inch, and are published in almost every book treating of the properties of steam. If copies of these tables are available, the value of H need not be calculated, but can be obtained from them in the following manner: As the pressure in the present problem is 94.7, the corresponding value for H will be less than that for 95 pounds by an amount equal to the product obtained by multiplying the difference between the values for 94 and 95 pounds respectively by 0.3. The value for 94 pounds absolute pressure is given as 1180.0, and that for 95 pounds as 1180.3 B. t. u. The difference between them is 0.3 B. t. u. Hence the value for 94.7 pounds equals 1180.3 — (0.3 × 0.3)=1180.3 — 0.09 = 1180.21. Subtracting 78 from this, as before, gives the heat required to convert a pound of water at a temperature of 110° F. into steam at a gauge pressure of 80 pounds, which will therefore be 1180 21 — 78 = 1102.21 B. t. u. The difference between the result, as calculated, and that obtained from tables is due to the difference in the number of decimal places employed in the two cases. (Trustees.)

6. How would you prepare lime for use in purifying gas?

Ans. Schilling, in the 1858 edition, page 75, gives the following direction :—

"The degree of moisture is of the greatest importance. In many works the rule is to slake the lime in such a manner that it will neither fall into powder nor adhere to the fingers when compressed. * * * * * In this condition, however, the lime is too dry; it causes much pressure. It is hardly possible to indicate precisely the quantity of water required for a given weight of lime, but there will be little danger of error in operating as follows: Spread the quicklime over a stone floor, and surround it with a slight dyke of slaked lime, to prevent the water from running off; then slake it with water thrown upon the mass. It is then to be well mixed and turned over,

until the whole forms a thick and homogeneous mass. It must then be thrown up in a heap, and left undisturbed until the next day, when it must be again worked over and the lumps broken."

Theobald Forstall later improved upon the Schilling method, and in a paper read before the American Gas Light Association, described his improvement in the following language:

"A simple and effective means of gauging the proper degree of moisture, and securing its uniformity throughout the whole charge of lime operated upon, is to pass the slaked lime through a wire screen, with an open mesh of one square inch area, placed at an angle of 70° degrees with the floor. This screening reduces the lumps into granular pellets of irregular form and size, the largest of which do not exceed the bulk of a small hickory nut. The proper degree of moisture is that beyond which any excess would cause the 'dough' to adhere to the screen instead of breaking through. Slight variations of moisture, in different portions of the charge, are corrected by the thorough mingling of the whole in the screening. The pellets do not adhere to one another spontaneously; they can be shoveled into barrows and reshoveled into the purifiers, without losing their independence; but the slightest compression and working in the hand will resolve them immediately into adhesive putty."

The Trustees recommend to the students that they read Mr. Forstall's paper, which may be found in the Proceedings of the American Gas Light Association for 1875; in the Journal of Gas Lighting, Vol. 26, page 364; or in King's Treatise, Vol. 1, page 425. (Trustees.)

7. What is the influence of heat upon the chemical reactions that occur in the purifiers, and what bearing does this influence have upon the question of the heating of purifying houses, lime rooms and revivifying rooms?

Ans. The chemical reactions occurring in the purifiers between lime or ferric oxide and the sulphuretted hydrogen (and in the case of lime the carbonic acid also) in the gas, are rendered more rapid and complete by heat. It has been found that at temperatures below 32° F. both lime and ferric oxide

are practically inactive with reference to sulphuretted hydrogen, and that, as the temperature increases, more and more of the impurities are absorbed, until at temperatures of 100° F. to 120° F. the action becomes as complete as it can be made under working conditions. It follows from this, that to secure good results in purification, purifying houses, lime rooms and revivifying sheds should always be maintained at a temperature not lower than 60°F., and further advantages may be derived from heating the gas itself, as it enters the purifiers, to a temperature of from 100° F. to 120° F. (Trustees.)

8. A cylindrical oil tank, placed with its axis horizontal, is 4′ 6″ in diameter and 24′ 0″ long. How would you determine the amount of oil it holds for every inch in depth of the oil from 1″ to 54″?

Ans. The simplest method of determining the amount of oil contained in a cylindrical oil tank set with its axis horizontal, when the tank is filled to certain levels, is a graphical one. On a piece of paper spread on a drawing-board or a smooth floor, draw a semicircle with a radius equal to that of the tank. Draw a line passing through the centre and stopping at each end at the circumference, or in other words draw a diameter of the circle. Then draw lines parallel to this diameter and 1″ apart until the whole semicircle has been divided into strips 1″ wide. The area is now divided into a number of quadrilaterals which are practically trapezoids, since the portion of the circumference included between adjacent lines is practically a straight line, with a segment of the circle at the bottom. An isosceles triangle, equivalent in area to this segment, can be formed by erecting a perpendicular at the middle point of the lowest one of the parallel lines, and from a point on this perpendicular a little outside of the circumference of the circle drawing a line on each side down to the base at the proper inclination to make it cut the circumference of the circle at such a point that the area included between the line, the circumference and the perpendicular and lying outside of the circumference, is equal to the area included between the line, the circumference and the lowest of the parallel lines and lying inside of the circumference. A very

close equality between these areas can be secured by eye after one or two trials. If the tank is a small one, and the curvature of the circumference sharp, it may be necessary to draw the parallel lines only ½″ apart in order not to have the portion of the circumference between two adjacent lines deviate too much from a straight line, and, in the present case, it is necessary to do this for the lower 10″ of the semicircle, the whole being thus divided into seventeen 1″ strips, nineteen ½″ strips, and segment having a height of ½″.

The semicircle having been divided up in this way, the calculations are very simple. Starting with the triangle, measure the lengths of its base and its altitude in inches, and multiply the base by one-half the altitude. The product is the area of the triangle in square inches. Multiply this by the length of the tank in inches, and the product is the volume in cubic inches of the space enclosed between the bottom of the tank and a plane parallel to the axis of the cylinder, and passing through a horizontal line drawn 1″ above the lowest point in the circumference. Divide this volume by 231 (the number of cubic inches in a gallon), and the quotient is the number of gallons in the tank when the liquid in it is 1″ high. Having determined this, the next step is to obtain the area of the trapezoid immediately above the triangle. To do this, measure the length in inches of each of its two parallel sides, add these lengths together, divide the sum by 2, and multiply the quotient so found by the length of the perpendicular between these sides, which will be either ½″ or 1″. The product is the area of the trapezoid. Multiply this by the length of tank in inches and divide by 231, and the quotient is the number of gallons contained in the portion of the tank included between two planes parallel to the axis and passing through the upper and lower sides, respectively, of the trapezoid. The sum of this number and of the number previously obtained is the total number of gallons in the tank when it is filled to the same height as the upper side of the trapezoid. In the same way the number of gallons that the tank will hold for each strip, represented by a trapezoid, can be determined and added to the total number of gallons for all the strips below it to get the total content of the tank up to that

point. When the contents have been figured for each inch up to the centre those for each inch above the centre can be obtained by adding, one at a time, the volumes of the corresponding strips as already determined, since each strip in one semicircle will have its counterpart in the other.

For the tank specified in the question the triangle judged to be equivalent to the segment with a height of ½″ has a base of 10.48″, and an altitude of .69″. Its area is, therefore, $10.48 \times 0.345 = 3.62$ square inches. In the trapezoid immediately above it the lengths of the parallel sides are 10.48″ and 14.76″ respectively, and the perpendicular distance between these sides is ½″. Its area is therefore $\frac{10.48 + 14.76}{2} \times \frac{1}{2} = \frac{25.24}{4}$ $= 6.31$ square inches and the total area of the segment with a height of 1″ is $3.62 + 6.31 = 9.93$ square inches. The length of the tank is 24′ or 288″, so that the volume contained when it is filled to a depth of 1″ is $9.93 \times 288 = 2859.84$ cubic inches, and the content in gallons is $\frac{2859.84}{231} = 12.4$ gallons. Working in this way, the number of gallons contained for each inch in depth of the oil can be found and a table made up from which to determine the content for any given measurement.

The areas of the different segments can also be calculated by any one of the several rules given in engineering handbooks, but it takes much longer to do the work in this way than by the graphical method, and the errors in the results obtained by the latter are well within the limits of error due to inequalities in the tank itself. For tanks over 8′ in diameter, however, the graphical method can hardly be used, on account of the difficulty of finding a suitable surface sufficiently large to hold the drawing. (Trustees.)

9. A calorimeter test made on a certain illuminating gas gave the following data: Gas consumed, 0.12 cubic feet; average temperature of water entering the calorimeter, 2.5° C.; average temperature of water leaving the calorimeter, 15.2° C.; quantity of water collected, 1509 c. c. (cubic centimetres); quantity of condensed water, 27 c. c. per cubic foot of gas; temperature of gas at metre, 46.5° F.; height of barometer, 29.33″. Calculate both the gross and net calorific value of the gas.

Ans Since, as stated in the Answer to Question No. 9, Seventh Series, a litre (1000 c. c.) of water weighs 1 kilogram and the amount of heat required to raise the temperature of 1 kilogram of water 1° centigrade is a calorie, the product obtained by multiplying the amount of water collected, measured in litres by the number of centigrade degrees by which its temperature is raised, is the number of calories absorbed by the water, and, consequently, the number produced by the combustion of the measured quantity of gas.

In the particular experiment noted, the water enters at a temperature of 2.5° C., and leaves at one of 15.2° C. The temperature is therefore raised 12.7° C. The volume of water collected is 1509 c. c. or 1.509 litres. The heat produced by the combustion of 0.12 cubic foot of gas is therefore $12.7 \times 1.509 = 19.16$ calories, and the gross calorific value per cubic foot, measured at a temperature of 46.5° F. and a barometric pressure of 29.33″, is 159.7 calories. A calorie equals 3.968 B. t. u., so the corresponding value is $159.7 \times 3.968 = 633.69$ B. t. u. But from the tables for the correction of the volume of gases, we find that the quantity of gas that occupies a volume of 1 cubic foot at a temperature of 46.5° F. and a pressure of 29.33″ will under the standard conditions of a temperature of 60° F. and a pressure of 30″, occupy a volume of 1.011 cubic feet. Consequently, the gross calorific value of a foot of the gas under test measured under the standard conditions, or as it is called the gross calorific value corrected for temperature and pressure, will be $\frac{633.69}{1.011} = 626.8$ B. t. u.

The net calorific value is obtained, as explained in the Answer to Question No. 9, Seventh Series, by deducting from the gross calorific value 2.38 B. t. u. for each cubic centimetre of condensed water collected per cubic foot of gas burned. In the present case, 27 c. c. of condensed water were collected, so the uncorrected net calorific value is equal to $633.69 - (27 \times 2.38) = 633.69 - 64.26 = 569.41$ B. t. u. To obtain the net calorific value, corrected for temperature and pressure, this must be divided by 1.011 for the reasons given above, and this corrected value is 563.2 B. t. u. (Trustees.)

10. It is desired to deliver 8,900 cubic feet of gas per hour through a pipe one mile long, with a loss of pressure of 0.4″.

The specific gravity of the gas is 0.58. What size pipe will be required? Give your calculations.

Ans. The answer to Question No. 11, Seventh Series, gives the formula by which the amount of gas flowing through pipes under different conditions can be calculated. This formula is,

$$Q=1350\sqrt{\frac{d^5p}{sl}},\text{ or as it is also written } Q=1350\,d^2\sqrt{\frac{dp}{sl}},$$

in which

Q=the number of cubic feet of gas delivered per hour,
d=the diameter of the pipe in inches,
p=the pressure, in inches of water, required for overcoming the friction in the pipe,
s=the specific gravity of the gas, air being 1.00, and
l=the length of pipe in yards.

Squaring both sides of the equation, we have

$$Q^2=1350^2\,\frac{d^5p}{sl}$$

Clearing of fractions gives

$$Q^2sl=1350^2d^5p,$$

and dividing both sides by 1350^2p

$$\frac{Q^2sl}{1350^2p}=d^5 \text{ or } d=\sqrt[5]{\frac{Q^2sl}{1350^2p}}$$

In the example given

Q=8900
p=0.4
s=0.58, and
l=1760 (1760 yards=1 mile)

$$\text{so } d^5=\frac{8900\times8900\times0.58\times1760}{1350\times1350\times0.4}=\frac{80,857,568,000}{729,000}=110,915.7 \text{ and}$$

$$d=\sqrt[5]{110,915.7}$$

To avoid having to perform the operation of extracting the 5th root, the result can be reached by finding from a table of logarithms the logarithm of 110,915.7, dividing this logarithm by 5, and then finding the number for which this quotient is the logarithm. The number so found is the desired 5th root. The logarithm of 110,915.7 is 5.0449930, and this, divided by 5, is 1.0089986, the number corresponding to which is

10.209. Therefore d = 10.209 in., and 12 in. pipe would be required.

Since the pipe chosen will be that of the standard size that is nearest to and larger than the exact size given by the formula, the result can also be reached by trial after finding the value of d^5. In the case in point, since 100,000 is the 5th power of 10 and 161,051 is the 5th power of 11, it is evident that the fifth root of 110,915.7 is a little greater than 10, and that therefore 12 in. pipe will be required.

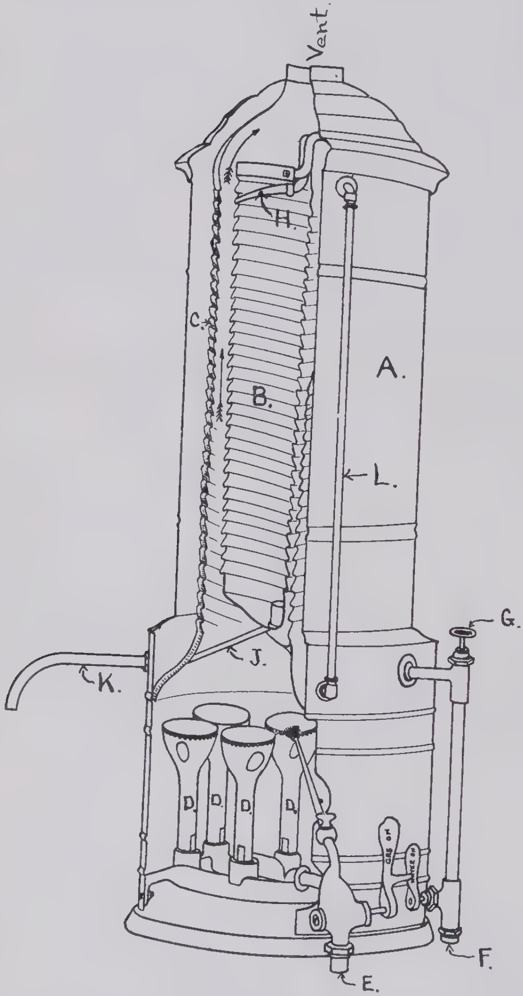
The problem has been worked out above, since it is important to know how to use the formula, but in practice problems of this kind are solved by the use of the gas-flow computer referred to in the answer to question No. 11, Seventh Series. (Trustees.)

11. Give a description, illustrated by sketches, of some form of instantaneous gas water-heater.

Ans. The name "Instantaneous" is given to a class of water-heaters in which the water is heated at the time when, and practically at the place at which, it is needed. Heaters of this class do not furnish any heated water to be stored up for future use and do not deliver water at sufficient head to enable it to be carried more than a few feet from the outlet of the heater itself. They work by causing the water that is to be heated to flow in thin streams over one surface of thin copper sheets, of comparatively large area, the other surface of these sheets being exposed to the heated products of the combustion of a comparatively large quantity of gas.

The heater illustrated on the accompanying cut consists of a copper cylinder, A, about 1 foot in diameter by 3 feet high, in which two spirally corrugated copper tubes, B and C, are set, the bottoms of these tubes being a sufficient distance above the bottom of the outer cylinder to leave ample space for the gas burners, D, D, D, and also for a combustion chamber, above these burners, in which the combustion of the gas can be completed before the products strike the water-cooled surfaces of the tubes. The inner tube, B, is provided with a closed bottom but is open on top. The outer tube, C, is fastened all around its bottom with a water-tight joint to the inside of the

outer cylinder, A, and its top fits snugly against the vent opening at the top of the cylinder. The axis of each of the



Instantaneous Water Heater.

tubes and that of the cylinder all coincide, and the annular space between the tubes is about 1″ wide.

Gas is supplied by means of a pipe, E, which should be ¾″ in diameter. A pilot light is used to light the gas at the main burners as shown. The lever of the main gas cock has on it an arm so arranged that as the gas cock is opened this arm opens the main water cock on the pipe, F. It is thus impossible to turn on the gas without turning on the water, and there is no danger of the heater being damaged by being exposed to excessive heat owing to the gas being turned on while the water is shut off. After passing the main cock the water goes through a regulating valve, G, by which the quantity flowing can be regulated to suit the requirements as to the temperature at which it is to be delivered. It is then carried, by a pipe inside the inner tube, up to the top of this tube. From the end of this main supply pipe branches are led to deliver the water directly on the inner surface of the inner tube and the outer surface of the outer one. One of these branches is shown at H. The water flowing over the inner tube follows the corrugations to the bottom, whence it flows through the pipe, J, into the bottom of the space between the outer tube and the cylinder, in which is also collected the water that has followed the corrugations of the outer tube. From this space it is delivered through one or more pipes, K, to the point, or points, where it is wanted.

As will be seen from the cut, the only outlet for the products of the combustion of the gas is up through the annular space between the corrugated tubes. This space being narrow, the products are brought into close contact with the metal and rapidly impart to it their heat to be taken up by the water flowing over it. As the products and the water travel in opposite directions, the water as it is heated flows over surfaces that are more and more highly heated and so is able to take up heat until it leaves the heater. The products of combustion, becoming cooler and cooler as they ascend, finally leave by the vent opening, which should always be connected to the outside air.

A gauge glass, L, is provided to show the height at which the water stands in the space between the outer tube and the cylinder, and thus call attention to the necessity for checking

the flow by the regulating valve should the water be running in faster than it can be carried off by the delivery pipes.

Heaters of the style shown on the cut contain 10 to 11 square feet of heating surface, will raise the temperature of the water by 50° F. when it is flowing at the rate of from 1½ to 2 gallons per minute, and will consume about 1 cubic foot of gas for each 1 to 1½ gallons of water heated.

As will be seen by the cut, the water and the products of combustion do not come into contact with one another in such heaters, and the water heated by them can be used for cooking as well as for washing. Another style of heater is made in which the water and products of combustion do come into contact with each other, and such heaters can be used only for water that is not to be taken internally. (Trustees.)

12. State some of the reasons for the increasing use of Portland cement concrete in the place of brick or stone masonry.

Ans. One of the principal reasons for the increased use of Portland cement concrete in the place of brick and stone masonry is found in the growth of knowledge as to the advantages and capabilities of concrete. When necessary, it can be made to excel in strength and durability all other masonry except that made from the very best stone, while when great strength is not required it can be made less strong, with a reduction in cost that cannot be had under similar circumstances with brick or stone masonry. On foundation work it can be put in with a smaller expense for excavation and will give a more coherent, homogeneous structure, and one that is less subject to unequal settling, in case the soil is not uniform over its whole area, than will be the case with stone. It can be made water tight more easily than brick or stone. Under ordinary conditions as to the respective costs of the different kinds of materials it is cheaper than brick or stone masonry.

In addition to the recognition of its possession of the advantages named above, another important reason for the increased use of concrete in large cities is that it can be made and put in place by unskilled labor, and work in which it is

used instead of brick or stone is thus free from the vexatious and costly delays that are apt to be experienced with other masonry, owing to the strikes declared for trivial causes by the masons' unions to which practically all the masons in such cities belong. This ability to use unskilled labor also frequently permits of the work being executed more rapidly on account of there being available more laborers than brick or stone masons. These considerations of freedom from union interference and ability to secure unskilled labor more easily than skilled, have been very important ones in large cities during the past few years. (Trustees.)

Twelfth Series of Questions—Sections of 1906—Practical Class—American Gas Light Association.

1. A net ton of one of two gas coals that are available for use yields 9,200 cu. ft. of gas, 750 lbs. of coke for sale, 10.5 gallons of tar and 4.5 lbs. of pure ammonia, while a net ton of the other yields 9,700 cu. ft. of gas, 850 lbs. of coke for sale, 15 gallons of tar and 5 lbs. of pure ammonia. The average make per retort per 24 hours is 8,300 cu. ft. with the first coal and 8,900 cu. ft. with the second. In both cases retort house labor costs $4.00 per each six retorts per 24 hours and the prices for the products are: Gas, $1.25 net per 1,000 cu. ft.; coke, $4.00 per net ton; tar 3c. per gallon, and ammonia, 5c. per pound. The first coal costs $2.40 per net ton. What is the equivalent price of the second?

2. Describe briefly and generally some method of charging and drawing gas retorts, in which hand labor is assisted by mechanical appliances, so arranged as to render the work easier and enable it to be done by fewer men.

3. Give a description, illustrated with sketches, of some form of hand pump used for pumping the drips on the inlet and outlet pipes of gas holders in brick tanks.

4. In the manufacture of carburetted water gas it has been found that with the ordinary methods of condensing and tar extracting some vapors remain in the gas until the purifiers are reached and are then deposited in the purifying material with the effect of shortening its life. What has been found to be an efficient way of removing these vapors before the purifiers are reached?

5. What is meant by electrolysis as applied to gas mains and what is its chief cause?

6. What are the respective advantages and disadvantages of cast and wrought iron pipes for use as gas mains?

7. Give a description, illustrated with sketches, of some form of recording pressure gauge used for taking street main pressures.

8. How should persons overcome by gas be treated?

9. In putting in gas piping that will be exposed to extreme cold, such as the risers in street lamp posts or the portions of mains on bridges, what method would you adopt to guard against the obstruction of the pipe by frost?

10. What is the "Principle of the Conservation of Energy," and how would you apply it to check up the claims made as to the results to be obtained from a new process for making gas?

11. Describe the cycle or series of operations and the method of governing employed in each of the following gas engines: Otto, Westinghouse and Körting.

12. Should the lining in the generator of the carburetted water gas apparatus be made single or double? Give the reasons for your answer.

(Answers to these questions are due February 1st, 1906.)

Answers to Twelfth Series of Questions—Section of 1906—Practical Class—American Gas Light Association.

1. A net ton of one of two gas coals that are available for use yields 9,200 cubic feet of gas, 750 pounds of coke for sale, 10.5 gallons of tar and 4.5 pounds of pure ammonia, while a net ton of the other yields 9,700 cubic feet of gas, 850 pounds of coke for sale, 15 gallons of tar and 5 pounds of pure ammonia. The average make per retort per 24 hours is 8,300 cubic feet with the first coal and 8,900 cubic feet with the second. In both cases retort house labor costs $4.00 per each six retorts per 24 hours and the prices for the products are: Gas, $1.25 net per 1,000 cubic feet; coke, $4.00 per net ton; tar, 3 cents per gallon, and ammonia, 5 cents per pound. The first coal costs $2.40 per net ton. What is the equivalent price of the second?

Answer. To solve the problem set in the question it is necessary to determine the price at which the second coal would have to be bought, in order to make the cost of gas in the holder per 1,000 cubic feet the same as it is with the first coal at $2.40. The only items in this cost that are taken as varying are the cost of coal and that of retort house labor. With coal No. 1 the net cost of coal, after deducting the value of the residuals produced, is,

Gross cost of coal		$2.40
Less—Coke 750 pounds @ $4.00 per 2,000 pounds	$1.50	
Tar 10.5 gallons @ 3c	.315	
Ammonia 4.5 pounds @ 5c	.225	
		2.04
Net cost of coal per ton		$0.36

As each ton of coal yield 9,200 cubic feet of gas the net cost of coal per 1,000 cubic feet is $\frac{36}{9.2} = 3.91$ cents. Since the retort house labor costs $4.00 per 24 hours for six retorts and the yield of gas per retort per 24 hours is 8,300 cubic feet the cost of retort house labor per 1,000 cubic feet is $\frac{400}{49.8} =$ 8.03 cents. With coal No. 1 at $2.40 per ton the combined

cost of coal net and retort house labor is therefore 3.91 cents + 8.03 cents = 11.94 cents.

In the case of coal No. 2 the cost of retort house labor being, as above, $4.00 per 24 hours for six retorts and the yield of gas per retort per 24 hours 8,900 cubic feet the cost of retort house labor per 1,000 cubic feet is $\frac{400}{53.4} = 7.49$ cents. As the cost of retort house labor and the net cost of coal are assumed to be the only variable items in the cost of the gas per 1,000 cubic feet in the holder the sum of these two items must be the same in the two cases to make this holder cost the same. Hence the net cost of coal per 1,000 cubic feet must be 11.94 cents—7.49 cents=4.45 cents. The yield of gas per ton being 9,700 cubic feet the corresponding net cost of coal per ton will be 9.7×4.45=43.2 cents and the gross cost will be,

Net cost of coal		$0.432
Add—Coke 850 pounds @ $4.00 per $2,000 pounds	$1.70	
Tar 15 gallons @ 3c	.45	
Ammonia 5 pounds @ 5c	.25	
		$2.40
Gross cost of coal per net ton		$2.832

or say $2.83. That is, the cost of gas per 1,000 cubic feet in the holder will be the same with coal No. 2 at $2.83 per net ton as it is with coal No. 1 at $2.40, and therefore $2.83 is the highest price per ton that can be paid for coal No. 2 in competition with coal No. 1 at $2.40 per net ton. (Trustees.)

2. Describe briefly and generally some method of charging and drawing gas retorts, in which hand labor is assisted by mechanical appliances, so arranged as to render the work easier and to enable it to be done by fewer men.

Ans. The appliances most commonly used for this purpose are those known as the West Manual Machines. The essential parts are a charging machine, a drawing machine, and a fixed overhead coal bin, from which a coal hopper on the charging machine is filled. There should also be an elevator of some kind to deliver the coal into the overhead bin, and provision must be made for reducing the coal used to a uniform size either by machinery or hand.

The charging machine consists of a coal hopper and the charging apparatus proper, which are suspended in such a way, from a square upright frame mounted on wheels, that both can be easily raised or lowered together by a chain winch, and fixed at the proper height for charging each tier of retorts. The wheels supporting the frame run on rails laid on the charging floor in front of and parallel to the retort stack, and the whole apparatus can be moved along the stack by means of a hand wheel geared to the wheels of the frame. The hopper is made with the ends or sides parallel to the stack verticle, and the other two sides tapering to a long narrow opening at the bottom, through which the coal is fed by a four bladed feeder, revolving in a feeder box riveted to the under side of the hopper. The charger, a light carriage or box running on three wheels, is supported on a platform just below this feeder box, in such a manner that it is free to move in a direction perpendicular to the face of the stack. Its bottom is formed of a pair of semi-circular scoops, so pivoted and geared that by simply twisting the long driving rod, they can be rotated in opposite directions through arcs of 90°, thus forming an open space through which the coal can drop.

The operation is as follows: The charging machine is run under the overhead bin and filled with coal enough for all the retorts of the series about to be handled, the charger is set at the proper height, and the machine moved into position in front of the first retort to be charged. A hinged flap is dropped forming a continuation of the charger platform into the mouthpiece. The operator then feeds the proper amount of coal for half a charge into the charger, by turning the feeder, pushes the charger to the back of the retort, twists the driving rod handle so that the scoops on the bottom of the charger rotate, and the coal drops on the bottom of the retort.

The charger is then withdrawn, refilled, again pushed into the retort until it strikes the coal already there, emptied and withdrawn, the flap raised, the whole machine moved to the next retort and the lid of the first retort closed. When all the retorts of a series are charged, the machine is moved under the overhead bin and the hopper again filled in readiness for

the next charge. A platform attached to the frame enables the operator to work to better advantage when charging the top tier of retorts.

The drawing machine is merely a frame on three wheels, which runs on the rails used for the charging machine, carrying an adjustable arm for supporting the rake. This arm is so arranged as not to interfere with the use of a wheelbarrow or coke buggy under the mouthpiece, and is adjusted to the different tiers of retorts by means of a simple hoisting tackle attached to the frame. A platform for use when working the top retorts is fitted to this machine also. The chief object and advantage of the drawing machine is, that it takes the weight of the rake off the stoker, who can thus use a rake with a larger head and work more rapidly. (Trustees.)

(For description of other stoking machines of the same class, see King's Treatise, Vol. 1, pages 285 and 286, Journal of Gas Lighting, etc. Vol. LXXIII, page 181, and Progressive Age, Vol. XV, page 427.)

3. Give a description, illustrated with sketches, of some form of hand pump used for pumping the drips on the inlet and outlet pipes of gas holders in brick tanks.

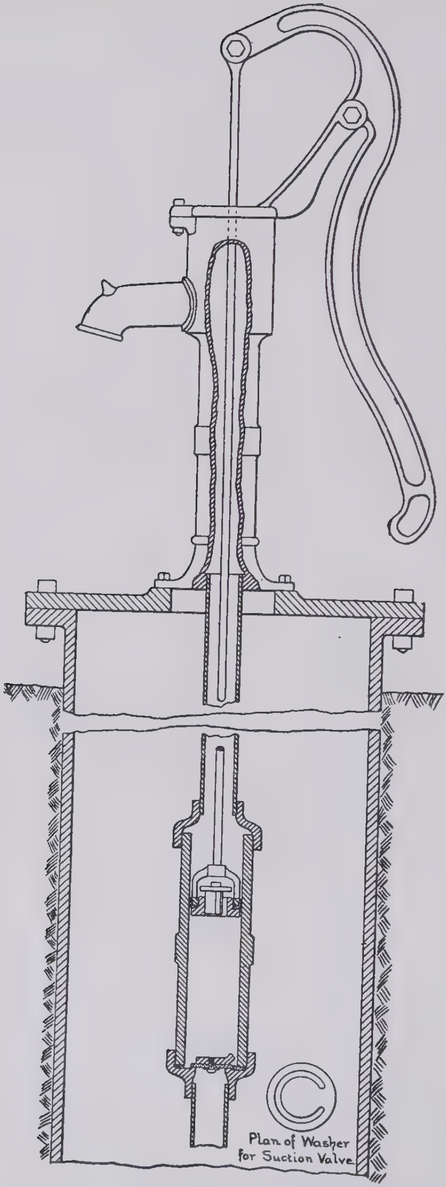
Ans. As the drips on the inlet and outlet pipes of gas holders in brick tanks are usually so far below the surface of the ground that an ordinary suction pump placed at the ground level would have too long a suction pipe to work satisfactorily, it is customary to use a form of deep well pump for pumping them. This kind of pump has the further advantage of being removed from any danger of freezing, so that it is not necessary to protect it from cold.

A form of deep well pump that is frequently used for gas holder drips is shown on the accompanying cut. The pump proper consists of a cylindrical cast iron barrel, of suitable diameter and length, threaded at each end to receive caps similar in form to reducing couplings, these caps being threaded to screw on the barrel and to receive a pipe of the desired size. The interior of the barrel is bored true. The piston is made in two parts, an upper and a lower. The upper part is an internally threaded ring, provided with a yoke

tapped for the insertion of the piston rod. On the outside the lower part of this ring is turned down to form a recess into which the upturned edge of a leather washer can fit. The lower part is in form like a bushing, but has no internal thread. The portion having the smaller diameter is threaded externally to fit the internal thread of the upper part of the piston, and its end is finished to furnish a seat for a cast iron poppet valve. These parts of the piston are not finished and have a little smaller diameter than the barrel, but it is made to work air- and water-tight in the barrel by a leather washer held between the two parts, and of such a diameter as to be turned up into the recess in the upper part when the piston is pushed into the barrel. When turned up in this way the tendency to flatten out keeps it pressed tightly against the wall of the barrel. In putting the piston together, the valve is put in place on top of the lower part, the leather washer is put on outside of the threaded portion of this part, and the two parts are then screwed together, the washer being held between them.

The bottom valve is formed by a leather washer cut to the shape shown on the cut. The outer ring of leather is held between the lower end of the barrel and the bottom cap, and the flap, weighted with a small circular cast iron weight fastened to it by a round headed screw and washer, acts as the valve, the narrow neck serving as a hinge. The lower cap is made with a raised ring finished to furnish a seat for this valve.

This pump is placed at any convenient height in the inlet or outlet pipe, being usually set from five to ten feet above the bottom of the drip, a suction pipe being run from the lower end to the bottom of the drip, and a discharge pipe from the upper end to the base of the stand which forms the external discharge pipe and furnishes a support for the handle by means of which the piston is moved up and down. This stand is in appearance exactly like an ordinary suction pump, but, of course, contains neither piston nor valves, being as stated simply a continuation of the discharge pipe. Its base is threaded internally to receive the pipe coming up from the pump barrel, and is provided with a flange by which it is bolted to the flange covering the top of the inlet or outlet pipe. This cover flange is provided in the center with a circular hole through which



Pump for Gasholder Drips.

the pump can be put in or taken out in case it is necessary to repair it.

Before being put into the pipe the suction pipe is screwed to the pump, the piston rod, which may be either a rod or a pipe, made the proper length, the discharge pipe screwed to the pump and then to the base of the stand, the piston rod fastened to the pump handle, and the whole thing is then put into place with the pump, supported from the stand, inside the pipe and at the desired height above the bottom of the drip.

A small hole should be drilled in the discharge pipe just above the pump, so that when pumping is stopped, the water in the stand and in the discharge pipe above this hole will run out and all danger of its freezing be avoided. A means of testing the working of the pump should also be provided by putting in a small pipe opening above the cover flange and running down into the drip to a point say 2″ above the lower end of the suction pipe. The upper end of this pipe being closed by a stopcock, this stopcock is opened when the pump ceases to raise water. If gas blows when this is done the drip is dry; if it does not the pump is out of order and should be repaired. (Trustees.)

4. In the manufacture of carburetted water gas it is found that with the use of ordinary methods of condensing and tar extracting some vapors remain in the gas until the purifiers are reached, and are then deposited in the purifying material, with the effect of shortening its life. What has been found to be an efficient way of removing these vapors before the purifiers are reached?

Ans. The method which has been finally settled upon, after much experiment, as being the most efficient in removing those vapors which still remain in carburetted water gas after it has passed through the ordinary condensing and scrubbing apparatus, but which if not removed would be absorbed by and clog the purifying material, is to pass the gas through a layer or layers of planer chips before it comes in contact with the purifying material. This may be done in the simplest manner by putting a layer of the chips on the lower tier of trays in each purifying box, so that when a box becomes the

first in the series the gas passes through this layer of chips and the vapors are strained out before the purifying material is reached. But this method, though simple, is more expensive in operation and not as efficient as the one adopted at several works where the planer chips are used in deep layers in separate vessels of the same form as the ordinary tower scrubbers, which may be called shaving scrubbers. When used in this way the chips can be changed at just the proper time as determined by their complete saturation and failure to arrest the vapors, while when used as a lower layer in the purifying box the changes are determined by the fouling of the purifying material, irrespective of the condition of the chips which may be called upon for more work than they are equal to, or, on the other hand, may have to be taken out of action before being completely saturated, thus making the action irregular, while at the same time the expense of handling into and out of the boxes is greater than it would be in the case of separate vessels.

A discussion of the subject, which should be read by the students, will be found in the Proceedings of the American Gas Light Association, Vol. XV., pages 142 to 147, and a paper describing the experiments made at one large works, and giving the details of the scrubbers used at that works, will be found in Vol. 17 of the same Proceedings, at page 207.

Since the reading of this paper further experiments have been made with modified forms of the P. and A. condenser, and one in which the drum is made of nine concentric cylinders formed from perforated sheets, with holes ⅛″ in diameter, has been found to remove all the tar and oil that cause trouble in the purifiers. The condensor is placed between the relief holder and the purifier, and is worked under a differential pressure of about 6″ to 9″. (Trustees.)

5. What is meant by electrolysis as applied to gas mains, and what is its chief cause?

Ans. When applied to gas mains electrolysis is used to denote the corrosion caused by the action of electric currents at the points where these currents leave the gas mains, along

which they have previously been traveling, to pass through damp earth to some other conductor that offers a path with a smaller resistance, or to pass through the earth around a joint offering a high electrical resistance. The process by which the corrosion takes place is exactly similar to what would happen if, in the often shown experiment of decomposing water by means of electricity, iron plates were substituted for the platinum plates that are used as the poles or electrodes. If this were done the oxygen that gathers around the positive electrode, or anode, would, in combination with the acid in the water, attack the iron and cause it to rust away. This is exactly what happens to the iron of a gas main when an electrical current passes from it into damp earth on its way to another conductor. Such earth almost always contains so-called salts, that is, substances formed by the combination of an acid and a base, which are soluble in water, and the current really travels through a solution of these salts. Such a solution is decomposed by the electricity into its acid and basic components, and the acid gathering around the positive electrode, which is the pipe at the place where the current leaves it, attacks the metal, the particles of which are carried with the current through the solution towards the negative electrode. The extent of the corrosion and the rapidity with which it takes place depend upon the amount of moisture in the earth, and the quality of current leaving the pipe. In very dry earth the action is very slow, but in earth that is quite moist it may, when sufficient current passes, proceed very rapidly.

The chief source of the electric currents which travel along the gas mains, and leaving them, set up electrolytic corrosion at the points of departure, are the return currents of single trolley wire electric railways. These return currents are supposed to travel back through the rails to points near the power house, from which they reach the negative side of the dynamos by means of return conductors bonded to the rails. As a matter of fact the greater or less quantity of current, the amount depending on the character of the bonding between the separate lengths of rails and the extent to which insulated return conductors are used, leaks into the ground and finds its

way to the gas and water pipes, which offer a path of small resistance as long as they run toward the power house. When the vicinity of the power house is reached, or when the pipes turn to go in a direction that takes them farther away from the power house, they no longer offer the path of least resistance, and the current leaves them to go back to the rails or to some other pipe that continues in the proper direction. As stated above, it is at the points where the current thus leaves the pipe that the electrolytic action occurs. The current may also leave the pipe at points where its conductivity is destroyed or reduced by a joint, even if it again returns to the pipe a little farther along, and electrolysis will also take place at such points.

Electrolysis of gas mains cannot be completely prevented as long as the rails are used as return conductors, but the extent to which it occurs can be reduced by careful bonding of the rails, by the provision of insulated return conductors connected to the rails at intervals, and by reducing the conductivity of the gas mains to as low a point as possible, so as to make them unattractive as paths for the stray currents.

A committee of the Western Gas Association made, in 1894, a very complete report upon the causes of electrolysis and the best means of preventing it. This report can be found in the Proceedings of the Association, at page 271 of the volume containing the report of the meeting in 1894, or in the American Gas Light Journal, Vol. LXI, page 765, or in Progressive Age, Vol. XII, page 222. (Trustees.)

6. What are the respective advantages and disadvantages of cast and wrought iron pipes for use as gas mains?

Ans. The advantages of cast iron, as compared with wrought iron pipe, for use as gas mains, are greater ability to withstand any corrosive action of the soil in which it is laid, and consequent longer life, greater thickness for equivalent internal diameters, giving a better joint for service connections tapped directly into the main and, in sizes from 6″ to 30″, inclusive, in diameter, smaller first cost. The disadvantages of cast iron pipe are, the necessity for a greater number of joints of a form more difficult to make tight originally, and to

keep tight throughout the life of the pipe, than is the form of joint used in wrought iron pipe, and the brittleness of cast iron, which renders it liable to break under shocks from extraordinary traffic on the street in which it is laid, or from strains thrown upon it through subsidences, due either to a disturbance of its foundation or to this foundation being originally insecure. The advantages and disadvantages of wrought iron pipe as compared with cast iron are of course the converse of the above.

In good soils cast iron will last indefinitely, and even under the worst conditions it will have a life of some years. Comparatively little wrought iron pipe has been used for gas mains, and none of this dates back far enough to furnish conclusive data as to the number of years that can be safely counted upon as the life, under ordinary gas distribution conditions, of such pipe when covered with a good protective coating of the kind described in the answer to a previous question. Experience with coated services shows, however, that when the conditions are at all bad, wrought iron corrodes much faster than cast iron, and that even under comparatively favorable conditions a very perfect coating is necessary to make a life of twenty to thirty years reasonably certain.

The greater thickness of cast iron pipes permits the securing of sufficient depth of thread to make a good screw joint in the wall of the pipe itself, so that there is no necessity for using the service clips or saddles, without which a good joint cannot be obtained with wrought iron pipe. The use of these clips adds not only to the cost of the services, but also to the opportunity for leakage at the service connections.

In the smaller sizes, 3″ and 4″, however, wrought iron pipe can be laid, under normal conditions of price, more cheaply than cast iron pipe, and in small towns or the residential suburbs of large cities, where the soil is good, the services will never average less than 50′ apart, and the probable consumption will never exceed the capacity of the above sizes, the advantages of wrought iron outweigh the disadvantage of possibly shorter life, and it is good practice to use it.

Another place where the use of wrought iron is advantageous is in the case of a line to be laid up a hill where the ditch

would have to be blasted out of rock, and where there is an opportunity to use a ditch already made for a sewer or a water pipe. A line of cast iron pipe could not be maintained in such a location, while the wrought iron pipe is strong enough not to be broken by any settling, and the line being laid on a slope there is little danger of its becoming trapped. (Trustees.)

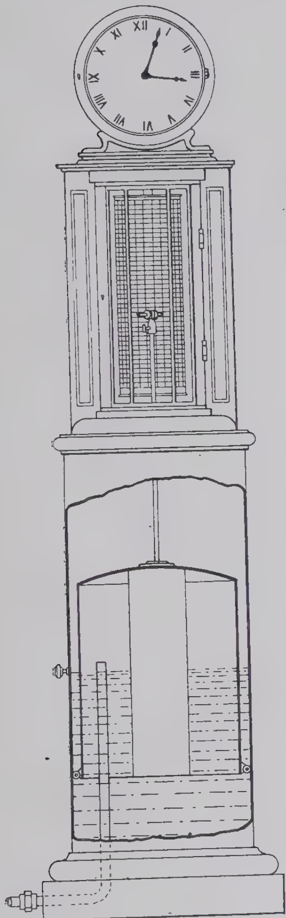
7. Give a description, illustrated with sketches, of some form of recording pressure gauge used for taking street main pressures.

Ans. The form of recording pressure gauge that it is desirable to use for taking street main pressures depends somewhat upon whether these pressures are to be taken, at any one location, continuously or for a day or two only. Where the pressures are to be taken continuously, as at the gas works or the gas office, it is best to use a gauge which measures the pressure by the height to which a small bell sealed in water is raised by the gas admitted under it, since such gauges are the least subject to get out of order and give inaccurate records. Where pressures are to be taken only for a day or two a year, it is advisable, for the sake of its greater portability, to use a gauge based on the aneroid barometer principle, even though it is necessary to exercise greater care in using it.

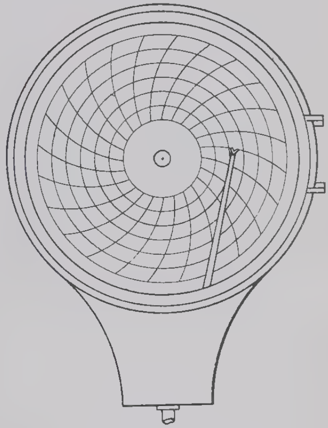
A gauge of the class first mentioned, which may be called a "Float Gauge," is shown, partly in elevation and partly in section, on the left half of the accompanying cut. Outwardly it consists of a tinned iron cylindrical case, containing the bell and the sealing water, and surmounted by a half cylinder, also of tinned iron, the front of which is closed by a glazed door in the shape of half of a hexagonal prism, which contains the recording apparatus. At the top is a clock by which the recording mechanism is driven.

The bell, by the motion of which the pressure is measured, is made of tinned iron, and is provided with a cylindrical float, made concentric with the bell, with such an area that when submerged in water to the full depth of the bell, the weight of the water that it displaces is just equal to that of the bell and its appurtenances, so that when the bell is at the lowest point to which it can sink, it is just afloat when the pressure

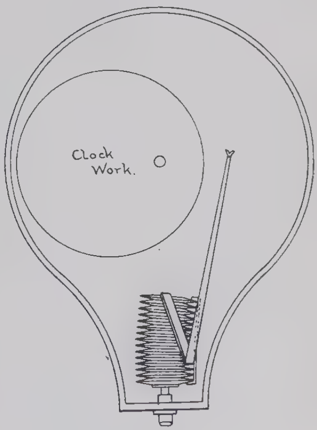
inside of it is equal to that of the atmosphere, and therefore is ready to rise as soon as the interior pressure exceeds that of the atmosphere. This bell is guided by wheels fastened around



Float Gauge.



Bristol Gauge.



Recording Pressure Gauges.

its lower edge and working on guides fastened to the case, and by a rod fastened to the centre of the top and passing up

through a small hole in the top of the lower part of the case into the space containing the recording mechanism. Gas from the street main, the pressure in which is to be recorded, is brought under the bell by means of a pipe entering through the base of the case and rising above the water line. A plug with a milled head is placed in the side of the case to drain off any water that may be run in above the water line and there is an outlet at the bottom for running off all the water. An opening, closed with a plug, is provided on the side of the case above the water line for putting in water when necessary. The stopcock on the gas pipe is usually made with a small side outlet, so that when the gas is shut off the interior of the bell is put into communication with the atmosphere through this side opening.

The height to which the bell will rise for each $\frac{1}{10}''$ gauge pressure possessed by the gas admitted under it, depends upon its weight, its height and the area of the annular space between the circumference of the bell and the float. It is evident that when the total pressure exerted by the gas on the crown of the bell is equal to the weight of the bell and its appurtenances the bell will rise to its full height, since the whole weight will be supported by the gas and therefore the float having no weight to carry will be forced up by the water until its bottom is on the level of the surface of the latter. The total pressure is equal to the gauge pressure of the gas multiplied by the area of the portion of the crown on which the pressure is exerted, and the weight in pounds that will be supported by this pressure is equal to the gauge pressure, in inches of water, multiplied by the area, in square inches, of the portion of the crown on which the pressure is exerted multiplied by 0.036, the weight, in pounds, of a cubic inch of water. Conversely the pressure in inches required to fully raise a bell, the weight and effective area of which are known, is equal to the weight divided by the product of the area and 0.036. In any given case, therefore, knowing the dimensions of the bell and of the float and the total weight, the pressure required to raise the bell to its full height can be calculated and by dividing the height by the number of tenths of an inch in the pressure so determined the amount of rise for each $\frac{1}{10}''$

of pressure is obtained. Or, since this rise must be just sufficient to reduce the volume of water displaced by the float by an amount the weight of which is just equal to the total pressure exerted on the top of the bell by a pressure of $\frac{1}{10}''$ of water, knowing the diameter of the float the rise can be calculated directly by dividing the product of the area, in square inches, of the annular space of the bell and 0.0036 by the product of the area, in square inches, of the float and 0.036, or, what is the same thing, as can be seen by canceling, by dividing the area, in square inches, of the annular space in the bell by the area of the float multiplied by 10.

The recording mechanism consists of a cylindrical drum supported on a central pivot at the bottom and connected by a central rod at the top to a shaft coming down from the clock. This connection is made in such a way that it can be readily broken and the drum removed. The shaft is so geared to the clockwork that it makes one complete revolution in twenty-four hours, carrying the drum with it when the connection is made. A sheet of paper ruled with vertical lines to show the time and horizontal lines for the pressure is wrapped around this drum and fastened so as to be carried around with it as it revolves. A pencil mounted on top of the rod carried by the bell is pressed by a light spring against the paper and makes a continuous line recording the pressure throughout the twenty-four hours. The vertical ruling marking the time is made by dividing the space equal in length to the circumference of the drum into twenty-four equal parts, so that in each hour one of these spaces passes under the pencil point. The proper distance between the horizontal lines marking the pressure is calculated in the manner explained above and the paper ruled accordingly. Both the vertical and horizontal lines are suitably marked to enable the pressure and time corresponding to any point on the sheet to be read off at a glance.

In starting a record the paper must be so placed on the drum, that when the bell is open to atmospheric pressure the pencil point touches the line of zero pressure at the point corresponding to the time at which the start is made.

The Bristol gauge, one of the second class, is illustrated on the right half of the cut. The lower figure shows the pressure

indicating mechanism and the upper figure shows a front view of the gauge with the card in place, so that the manner in which this card is ruled can be seen.

Both the indicating and the recording mechanism are contained in one cast iron case, which is a shallow box of an inverted pear-shaped section. The elongated part at the bottom is covered over with a solid cover, while the upper part is provided with a circular, glazed door.

The pressure indicating mechanism, contained in the elongated portion of the case, consists of a number of rings made of thin corrugated brass fastened together so as form a gas-tight vessel similar to an accordion in shape. The corrugations on each ring are arranged in circles concentric with its edges. The metal being very thin the effect of even a very slight increase in the pressure inside the vessel is to flatten the corrugations, thus increasing the width of the rings and producing an elongation of the vessel. When one side is prevented from lengthening by means of a flexible strip, placed against it and fastened to the top and bottom rings by turned-over ends, the effect of the pressure is to cause the vessel to become curved, the top plate being tilted and its centre thrown off the vertical line to the side on which the strip is fastened. The greater the pressure the greater the curvature and the greater the tilting of the top plate and the displacement of its center from the vertical line. By means of this tilting and displacement, the point of a bent arm attached to the top plate of the vessel is moved, along the arc of a circle, farther away from the vertical line as the pressure increases.

The record of pressures is obtained by providing the point of this arm with means of making a continuous line on a circular card fastened to a plate, which is caused by clockwork to make one revolution in twenty-four hours. The pressure lines are concentric circles placed the proper distance apart, while the lines marking the time are arcs of circles corresponding to the arc along which the marking point travels as the pressure rises and falls. Both sets of lines are so marked as to enable the pressure and time corresponding to any point on the card to be noted at a glance.

Owing to the lightness of its parts a gauge of this kind cannot stand rough usage and must be very carefully handled to prevent its getting out of order and to keep it accurate. (Trustees.)

8. How should persons overcome by gas be treated?

Ans. The following answer to this question has been taken by permission of the company from the book, "First Aid for Persons Overcome by Gas," issued by the United Gas Improvement Company for the use of its subordinates.

"When persons are affected by illuminating gases, they are in one of three classes:

"*Class I.* Those slightly affected—headache, dizziness and nausea, but still entirely conscious.

"*Class II.* Those seriously affected, but still breathing.

"*Class III.* Those apparently dead—not breathing.

"To properly treat these three classes, it is necessary to have on hand in an Emergency Kit the following materials:

"(*a*) A bottle of Weiss beer;

"(*b*) A bottle of aromatic spirits of ammonia;

"(*c*) A bottle of ordinary ammonia, with sponge attachment;

"(*d*) A tin cup;

"(*e*) A pair of tongue-pliers;

"(*f*) A towel.

Class I.

"*Symptoms:*—Those slightly affected, complaining of headache, dizziness, nausea or vomiting and great drowsiness, with relaxation of muscles, hurried breathing and rapid heart action.

"*Treatment:*—Take the patient immediately into fresh air, loosen collar and open shirt, at the same time walking him around, as shown in Figure No. 1. Give Weiss beer while walking, as shown in Figure No. 2, followed in five minutes by a half teaspoonful of aromatic spirits of ammonia in a third of a glass of water. This dose may be repeated every fifteen minutes for not more than four doses. Walk him

around until he recovers; then watch him, as he may have a sinking spell, in which event the same treatment must be renewed.

"Weiss beer is given to lift from the patient's stomach any gas he may have swallowed. It is easier to give than soda

Fig. No. 1.

water because the neck of the bottle is of a shape which can be readily thrust into the patient's mouth and held there while the liquid is being poured. However, if Weiss beer is not obtainable, plain soda-water will do. Aromatic spirits of ammonia is given as a stimulant for the heart and lungs, both

of which are weakened by the effects of gas. In walking the patient, two men should support him, with one of his arms around the neck of each, as shown in Figure No. 1. If the patient is unable to assist in walking, or if at any time he ceases to walk, so that the toes of his shoes drag, as shown in

Fig. No. 2.

Figure No. 3, it is a sign that he has entered the second class of cases. When this happens the walking should be stopped and the patient should be placed on his back and treated as explained in Class II. below.

Class II.

"*Symptoms:*—Those seriously affected, but *still breathing.* The patient is apparently "knocked out;" he is either half conscious or unconscious—very weak, and his breathing is rapid and weak.

Fig. No. 3.

"*Treatment:*—*Send for a doctor at once.* Carry the patient immediately into fresh air. In this class of cases, he is too weak to walk, and is unable to swallow Weiss beer. Place him on his back on a flat surface, with a coat rolled (not folded) under the shoulders and neck, in such a way as to

allow the head to fall backward enough to straighten the windpipe, as shown in Figure No. 4; at the same time open the shirt wide at neck and loosen the trousers and drawers at waist, and have two assistants rub his legs and arms hard. The sleeves and trouser legs should be rolled up as far as possible so that the rubbing may be done on the bare skin, as shown in Figure No. 4.

"If he is conscious enough to swallow, give him a half-teaspoonful of aromatic spirits of ammonia in a third of a

Fig. No. 4.

glass of water. This dose may be repeated every fifteen minutes for not more than four doses.

"If unconscious, open his mouth, forcing the jaw if necessary.

"(If the jaw is rigid, it can be forced open by placing the forefingers back of the bend of the lower jaw-bone and the thumbs of both hands on the chin, pulling forward with fingers and pressing jaw open with thumbs, as shown in Figure No. 5.)

Fig. No. 5.

"Place something between the teeth to keep the jaws open and prevent the patient from biting his tongue, using something large enough to prevent any danger of his swallowing it accidentally, and grasp his tongue with the tongue-pliers, as shown in Figure No. 6.

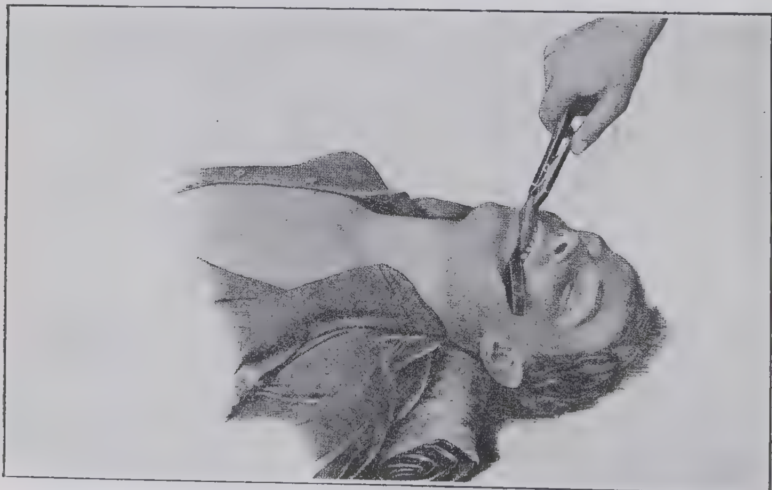


Fig. No. 6.

Fig. No. 7.

"Clear froth from the mouth by putting in your forefinger as far as possible, and bringing up the froth with a scooping motion. Have the assistant who is holding the tongue slowly pass the bottle of ammonia with a sponge attachment under

Fig. No. 8.

the patient's nose about once a minute, as the patient breathes in, as shown in Figure No. 7.

Help the patient to breathe by pressing the *base of the ribs* together *every other* time he breathes out, as shown in Figure No. 7. Do not press vertically, but press on the patient's side (palms of hands over lower ribs) in such a manner as to force as much air out of the lungs as possible. You can carry out this pressing action most successfully if, on beginning, you move your hands in and out with every breath, pressing very lightly, until you have established a rythmical motion of your hands in unison with the patient's breathing; then you can begin to press hard at *every other* out-going breath.

"(The object of doing this is to strengthen his breathing. By making the pressure *every other* time he breathes out, you give him an opportunity to take a breath himself, and this natural effort to breathe is in itself strengthening to the action of the lungs.)

"Continue this pressing action until the man is conscious and breathing well by himself.

"The rubbing of the arms and legs, as shown in Figure No. 7, the holding of the tongue, and the passing of the bottle of ammonia with the sponge attachment under the nose, should be continued as long as the pressing action is necessary. After he is conscious give him a half-teaspoonful of aromatic spirits of ammonia in a third of a glass of water. After you have brought him around, shift the coat or pillow from under his shoulders to under his head—see Figure No. 8—and surround him with bottles of hot water, as shown in Figure No. 8.

"(Beer bottles are easily obtained, and should be filled with hot water and covered with paper or cloth to prevent burning the flesh. Hot bricks also covered, or gas bags filled with hot water will answer as well.)

"Then cover him with a coat and watch him.

Class III.

"*Symptoms:*—Those apparently dead—not breathing at all.

"*Treatment:—Send for a doctor at once*, in the meantime acting as follows: Carry the patient immediately into fresh air.

Place him on his back on a flat surface, with a coat rolled (not folded) under the shoulders and neck, in such a way as to allow the head to fall backward enough to straighten the wind-pipe, as shown in Figure No. 4, at the same time open the shirt wide at neck and loosen the trousers and drawers at waist, and have an assistant rub his legs hard.

"(The sleeves and trouser-legs should be rolled up as far as possible, so that the rubbing may be done on the bare skin, and the shirt and undershirt should be torn down the front so that they may be thrown back, leaving the chest and stomach bare, as shown in Figure No. 13.)

"Open his mouth, forcing the jaw if necessary in the manner previously explained.

"Place something between the teeth to keep the jaws open and to prevent the patient biting his tongue, using something large enough to prevent any danger of his swallowing it accidentally, grasp the tongue with the tongue-pliers, as shown in Figure No. 6, having an assistant hold it out while you are helping the patient to breathe, as described below.

"(In the absence of tongue-pliers, the tongue may be grasped between the index and second fingers, after they have been covered with a handkerchief.)

"Clear froth from the mouth by putting in your forefinger as far as possible and bringing up the froth with a scooping motion. Have the assistant who is holding the tongue slowly pass the bottle of ammonia with sponge attachment under the patient's nose about once a minute, when the patient is breathing in, and when his arms are being extended above his head, as shown in Figure No. 13.

"While you are preparing the patient as just described, an assistant should force the air out of the lungs by pressing the *base of the ribs* together about once every four seconds, as described in Class II. and shown in Figure No. 7.

"After the clothing has been loosened, the jaw forced open, as shown in Figure No. 5, the froth cleared from the mouth and the tongue grasped, begin artificial breathing at once as follows:

Fig. No. 9.

ARTIFICIAL BREATHING.

"Kneel far enough behind the head of the patient to prevent interference with the man holding the tongue. Bend the patient's arms so that the hands meet on the chest; grasp the

Fig. No. 10.

Fig. No. 11.

patient's forearms firmly, as close as possible to the bent elbows.

"I. Firmly press the patient's elbows against the sides of his body so as to drive the air and gas out of the lungs, as shown in Figure No. 9; then

Fig. No. 12.

"II. Raise the arms slowly with a sweeping motion until the patient's hands meet above (or behind) the patient's head, as shown in Figure No. 10; then

"III. While you have the patient's arms stretched out in line with his body, give them a slow strong pull until you have expanded or raised his chest as high as it will go, as shown in Figure No. 11; then

"IV. Bring the arms, with bent elbows, down against the sides, and firmly press them as before, as shown in Figure No. 9.

Fig. No. 13.

"This action should be continued about fifteen times a minute until the patient begins to breathe. You must guard against a tendency to make these motions too fast; they must be done slowly. A good plan is to count four slowly—'one,' as the pressure is given on the sides, as shown in Figure No. 9; 'two,' as the arms are being above the head, as shown in Figure No. 10; 'three,' as the strong pull is given, as shown in Figure No. 11; and 'four,' when the arms are again being bent and returned to the sides, as shown in Figure No. 12.

"Do not let your hands on the fore-arms slip away from the

elbows; the best result comes from grasping close to the elbows, as shown in Figure No. 12.

"The operator must appreciate the fact that this manipulation must be executed with *methodical deliberation*, just as described, and never hurriedly or half-heartedly. *To grasp the arms and move them rapidly up and down like a pump-handle is both absurd and absolutely useless.*

"Each time the arms are pulled above the head and the chest expanded, the assistant who is holding the tongue should pull the tongue out and downward, and another assistant should, from time to time, slap the chest with the towel or cloth wet with cold water, as shown in Figure No. 13.

"When the patient is breathing by himself, the process of artificial breathing can be stopped, but the process of pressing the sides *every other* time he breaths out, as described in Class II., and shown in Figure No. 7, should be again started and continued until he can breath naturally (not too hurriedly) without assistance.

"The rubbing of the legs should continue as long as the artificial breathing, or pressing action, is necessary, and the holding of the tongue, and the passing of the bottle of ammonia with sponge attachment under the nose as long as he is unconscious, as shown in Figure No. 7.

"After he becomes conscious, give him a half-teaspoonful of aromatic spirits of ammonia in a third of a glass of water. After you have brought him around, surround him with bottles of hot water.

"Then cover him with a coat and watch him.

"In performing artificial breathing, if the patient does not show any signs of coming to life promptly, you should not be discouraged, but should continue the motions regularly for *at least one hour*, summoning such assistance as you may need. Cases are known where patients showing no signs of life after an hour's work have still recovered, and their recovery was due entirely to the faithful persistence of the person in charge.

"Persons who are affected by gas need *fresh* air; therefore, bystanders should not be permitted to crowd around the

patient, and no one should be allowed to approach the patient except those carrying out these instructions.

"Should the articles contained in the Company's Emergency Kit for Asphyxiation Cases not be on hand when needed, a doctor should be sent for at once, and in the meantime every effort should be made to revive the patient, by following the course of movements described, until the doctor arrives and the necessary articles are secured."

9. In putting in gas piping that will be exposed to extreme cold, such as the risers in street lamp posts or the portions of mains on bridges, what method would you adopt to guard against the obstruction of the pipe by frost?

Ans. Obstructions to gas pipes from frost may be guarded against either,

By enlarging the portion of the pipe in which the frost tends to accumulate, to such an extent that a passage of sufficient size will remain for the gas even after the frost has accumulated on the interior surface of the pipe to a thickness that makes it an efficient non-conductor of heat and so prevents any further formation, or

By covering the outside of the pipe with a non-conducting coating which prevents the gas from being cooled to the frost-producing temperature, or,

By providing means for readily removing the frost when it has collected in sufficient quantity to begin to unduly restrict the flow of gas through the pipe.

The first method is preferable wherever the extra size of pipe called for is neither inconvenient nor expensive. It is applied to lamp risers by the use of about thirty inches of 1½" pipe, called an "anti-freezer," extending up from the service to about one foot above ground. The remainder of the lamp riser is of the usual size, ¾" or ½", and the greater area of the 1½" pipe allows much frost to be deposited in it, before it is closed up, and it is found in practice, that in the latitude of the Northern States the winters are seldom severe enough to cause the anti-freezer to become stopped up. The location of the anti-freezer, just where the gas goes through the cold ground and first strikes the air, ensures that all condensation

will occur in it. For bridge crossings, where the main is small, 6″, or less, in diameter, this method is applied by increasing the diameter of the pipe by 2″ from a point in advance of that at which the exposure to cold begins on one side to a point beyond that at which this exposure ends on the other side. If the pipe rises from the ground to cross on top of the bridge, the larger size should be used from the beginning of the rise on the one side to the end of the drop on the other, while if the pipe crosses under the bridge and on practically the level at which it is laid on the approaches, the enlargement should be made on each side at a distance back from the face of the abutment at least equal to the depth to which the pipe is covered plus one foot. When wrought iron pipe is used for the crossing, a piece of pipe of the same size as the main in the ground is sometimes inserted loosely in the enlarged portion, as a precaution against the obstruction of the passage by accumulations, on the bottom, of frost shaken loose from the top, the two pipes being kept concentric by proper distance pieces. The frost forms in the annular space and leaves the inner pipe entirely unobstructed and surrounded by a good non-conductor.

When the pipe is small and the conditions are such that a non-conducting covering on the outside of the pipe can be applied cheaply, and will not be exposed to undue wear and tear, the second method is preferable to either of the others.

The third method, that of providing means for dissolving, or otherwise removing, frost as it forms, is to be preferred to the others in case of large pipe on bridges. Where the supply demands a pipe 6″ or larger, and the climate is so severe that frost enough would form to seriously diminish or to stop the flow of gas, openings should be provided in the bridge line for the introduction of a solvent for the frost, such as wood alcohol. Ordinarily, holes tapped in the line at high points, say about twenty feet apart, will suffice. One or two such holes should also be provided in case of emergency, even when the method of enlargement is adopted. In very large lines, 16″ and over in size, tees might be put on each side of the bridge where the line comes out of the ground, the free outlets of these tees being made flanged and closed with blank flanges.

This would provide against extremely large deposits of frost, for full access to the line would be obtained by removing these flanges. There should be a valve on each side of the bridge to permit the bridge line to be cut out. Where the bridge line furnished the only supply to the district on the further side, a temporary by-pass line would have to be laid before the valves were closed. (Trustees.)

10. What is the "Principle of the Conservation of Energy," and how would you apply it to check up the claims made as to the results to be obtained from a new process for making gas?

Ans. The "Principle of the Conservation of Energy," is, that the total energy of the universe is constant, no energy being created or destroyed in any of the processes of nature, every gain or loss in one form of energy corresponding precisely to a loss or gain in some other form or forms. (Century Dictionary.)

This principle follows from the still broader one, that "all that exists, whether matter or force, and in whatever form, is indestructible by any finite power," the truth of which has been, and is being, more and more firmly established by all the researches of science.

From it we reason, that in no case can the sum of the energies (actual and potential) possessed by the products of any combination of different forces or bodies be greater than the sum of the energies possessed by the original forces or bodies before they entered into combination. And in regard to machines, "that it is impossible by any combination of natural forces to make a machine, whose parts being once set in motion and then left to the operation of gravity, or other similar forces, and their own mutual action, shall later return to their original positions with greater velocities" (and consequently greater energies) "than they at first possessed;" or, in other words, it is impossible to make "a machine, which being put into motion, and left to itself, will, in a certain time, regain its original velocity, and at the same time impart to some body, originally at rest, a certain velocity."

To apply this principle to check up the claims made as to

the results obtained from any process for making gas, it is merely necessary to determine the relation between the sum of the energies possessed by the products of the process and the sum of the energies possessed by the raw materials employed, bearing in mind that the energies possessed by the products not only can never exceed the energies possessed by the raw materials, but will never even equal them, since in making gas it is impossible to avoid losses by radiation of heat, and also by heat carried away in the waste products. If, when the claims put forth are analyzed, it is seen that the total energy claimed to be available as a result of the process is greater than, or even exactly equal to, the total energy put in, these claims can safely be dismissed as absurd. In many cases it is very easy to disprove the claims made as to the results of gas making processes by a comparison between the sum of the heating values of the materials employed and that of the same values of the products; and although it may be difficult to make the comparison in some cases, it will, when properly made, always tell whether the results reported are reasonable or not. (Trustees.)

11. Describe the cycle or series of operations and the method of governing employed in each of the following gas engines, Otto, Westinghouse, and Körting.

Ans. The Otto engine employs the Beau de Rochas cycle in a single acting cylinder, occupying four consecutive piston strokes as follows:

1. First out-stroke drawing in the charge of air and gas.
2. First in-stroke compressing the charge.
3. Ignition at dead point with explosion of charge followed by second out-stroke and expansion of the hot gases.
4. Second in-stroke discharging the products of combustion from the space swept through by the piston, but not from the clearance space.

In this cycle, which is the one most commonly employed at the present day in small engines using illuminating gas, the third stroke is the only one during which work is done on the crank shaft, all three of the other strokes absorbing part of

the power generated by the explosion and stored up in the fly-wheel during this single stroke.

The Otto engine is governed on what is known as the "hit or miss" principle, that is, either a full charge or no charge at all is taken into the cylinder and exploded, the governor working on the gas valve in such a way that no gas is admitted to the cylinder as long as the engine is running at its normal speed, the valve opening only when the number of revolutions falls below that for which the governor is set. Thus when running on a light load the engine may miss either every other explosion or two out of every three, or so on, according to the load. This method of governing by admitting charges of full size only, makes the degree of compression of every charge the same and thus causes all the gas to be employed under the most economical conditions for any particular engine, but it permits, in fact depends upon, comparatively wide variations in speed, and therefore is not satisfactory when close speed regulation is important.

The Westinghouse gas engine also employs the Beau de Rochas four stroke cycle, but has always two cylinders, and in the larger examples three, the pistons working in which are connected to the same crank shaft, thus securing in the smaller sizes one working stroke to each revolution, and in the larger three working strokes to each two revolutions.

The speed is governed, not by the "hit or miss" method of doing away with the explosions entirely when the speed runs above the normal, but by regulating the amount of the explosive mixture admitted to the cylinder in each complete cycle in a manner similar to that employed for governing steam engines. In this way an explosion is secured in each cylinder for each four strokes, but the force of the explosions is varied in accordance with the amount of work to be done. The ports of the valves regulating the admission of gas and air to the cylinder are so arranged that their areas can be adjusted to give a mixture containing the desired proportions of air and gas entirely apart from the action of the governor, which simply controls the length of stroke of these valves, so that varying quantities of a mixture containing always the same proportions of air and gas (so long as the adjustment

spoken of above is unchanged) are admitted into the cylinder. This method of governing keeps the speed more uniform than the "hit or miss" method, but since the volume of the charge is varied for each cycle, the amount of compression is also varied and the engine is not always working at the most economical degree of compression. For this reason an engine so governed uses more gas per horse power per hour, other things being equal, than does one governed in the other way. However, when the work to be done calls for great uniformity of speed the loss in economy may easily be more than counterbalanced by the closer speed regulation, especially when gas is cheap.

As originally made in small sizes the Körting engine also employed the Beau de Rochas cycle in a single acting cylinder, the governing being done by varying the strength of the charges. As now made in large sizes, 500 H. P. and over, with especial reference to the use of blast-furnace gas the Körting is a two-cycle double acting engine, with two explosions for every revolution. The two-cycle working in the main engine cylinder is secured by the use of two auxiliary pump cylinders, one being used for air and the other for gas. These two pump cylinders are in line and their pistons are fastened on a common rod and driven by a crank set at an angle of 110° in advance of the main crank of the engine. The connections between the pumps and the main cylinder are such that gas and air from the rear end of the pumps can pass only to the rear end of the cylinder and vice versa.

Considering the main piston as starting from the rear end of the cylinder it travels forward until it uncovers the exhaust ports, which are located in the middle of the cylinder and are unprovided with valves, being opened and closed by the main piston itself. As soon as these ports are uncovered the pressure in the rear of the cylinder falls to atmospheric, and the admission valve is opened slightly before the piston reaches the end of the forward stroke. During the latter part of the forward travel of the main piston the pump pistons have been traveling backwards and air has been compressed into the air pressure pipe. The gas pump valves are so arranged that the gas is not compressed at as early a point

in the stroke as is the air, and as the air pressure pipe and the gas pressure pipe both deliver into a common valve chamber, the opening from which into the cylinder is controlled by a single valve, the air which is being delivered at a higher pressure at the moment the admission valve opens forces back the gas and at first only air enters the cylinder. The exhaust ports being still uncovered this air first forces the products of combustion out of the cylinder and then, as the ports are closed, is supposed to form a layer next to the piston, leaving at the back of the cylinder a mixture richer in gas than would be the case if gas were admitted from the first. As the pump piston travels back the gas becomes compressed in the rear end of the gas pump, and, the excess of pressure in the air pipe and the rear end of the air pump having been reduced by the escape of part of the air into the main cylinder at atmospheric pressure, both air and gas pass into the cylinder until the admission valve closes as the pump pistons reach the rear ends of the cylinders. The proper proportion between gas and air is secured by having the areas of the air and gas cylinders bear the desired relation to each other.

By the time the admission valve closes the engine piston has traveled through almost half of its backward stroke. During the rest of this stroke the mixture of air and gas is compressed and when the stroke is completed this mixture is ignited, and by its combustion forces the piston out on the forward stroke. An exactly similar set of operations occur in the forward ends of the main cylinder and the pump cylinders, and is repeated at each end of the cylinders for each revolution.

The governing of the Körting engine is done by varying the strength of the charge, but in a different manner from that employed in the Westinghouse. In the latter the proportion between the amounts of air and gas is always the same, no matter how small the charge. In the former the quantity of air admitted is not changed, the governor controlling only the quantity of gas used. This is done by changing the time at which compression begins in the gas pump and thus the time at which gas begins to enter the engine cylinder, the admission of gas being advanced or retarded as more or less power is required. During the time that the gas is entering the

cylinder it is mixed with the chosen proportion of air, and it is claimed that this mixture forms a layer at the end of the cylinder and is not diffused to any great extent through the air that is first admitted, and that thus certainty of ignition is secured even with small quantities of gas. The volume of air being the same for every charge the total volume of the charge and therefore the degree of compression does not vary as much as in the case of engines governed as is the Westinghouse. (Trustees.)

12. Should the lining in the generator of a carburetted water gas apparatus be made single or double? Give the reasons for your answer.

Ans. The lining for the generator of carburetted water gas apparatus can be made of single courses of blocks having the desired thickness, except for that portion of the height extending from just below the level of the grate bars to a point 4′ above these bars, or even 5′ above, if the fuel used is such that clinker forms against the wall to an unusual height, where it should be made with inner and outer courses whose combined thickness, including that of the joint between them, is equal to that of the single courses used above and below.

Except at the place mentioned the lining is not subject to any considerable wear, and should not have to be renewed more than once in four to five years. A single course of thick blocks can be made and put in place more cheaply than two courses of thinner blocks, and therefore is to be preferred where the wear and tear is inconsiderable. For a height of 3′ or 4′ above the grate, however, the inner surface of the lining is subjected to a great deal of wear, on account of the formation, during the operation of the apparatus, of hard clinker, which adheres tightly to the wall of this portion of the generator, and has to be cut away from it with heavy steel bars each time the fire is cleaned. Even when the greatest care is taken not to injure it, the wall is sure to suffer from this cutting in the course of no great length of time, and this part of the lining of the generator must be renewed at intervals of from one to two years. If it is made in a single course of blocks the whole of the lining within the clinker zone must be taken out and replaced at these times, while if made in two courses it is only

necessary to renew the inner course. In any case the work must be done before the thickness of the whole lining is reduced to that of the outer course of the two, so that the intervals between renewals cannot be made any longer with a single lining, and the extra cost of renewing a single lining as compared with that of renewing only the inner course of a double cannot be offset in this way. A double lining for this part of the generator is therefore more economical in the long run even though it may cost slightly more at first.

If, as is sometimes the case, a double lining is used throughout, at least two courses of single lining should be put in immediately above the courses that require frequent renewing in order to hold up the inner courses of the wall above them while the work is under way. If these single courses are not provided, it is necessary to support the upper part of the wall when relining, and this adds to the length of time required to do the work of relining as well as to the cost of this work. (Trustees.)

Circular to Members of the Section of 1909, Practical Class.

You will find enclosed the first series of twelve questions for your section. A similar series will be sent out each three months, but no series will be sent to any member of the class who has not sent in answers to the questions of the preceding series within the time specified for the receipt of such answers, or failing this has secured an extension of time by presenting to the Secretary a good and valid excuse for such failure. All answers will be carefully examined by the Secretary, and each member of the regular class will be sent a criticism of his work on each series of questions based upon such examination. Members of the class should therefore keep copies of their answers in order to fully understand the criticism. Those members of the class who answer all the questions as sent out will be continued in the class for three years, this period having been fixed upon by the Trustees as the length of time to be given to the course.

Before making up their answers the students are at liberty

to use any and all means of securing information at their disposal, with the following exception. Some of the questions having already been used for previous sections, the answers to them have been published in the Proceedings of the American Gas Light Association. The answers thus published should not be consulted by the student while preparing his answers. Answers should be written in the student's own language, based upon the knowledge acquired through his study of the subjects covered by the questions, and not copied directly from any text book or other source of information, and care should be taken that the desired meaning is clearly and concisely expressed, and that reasons are given for the statements made.

It is assumed by the Trustees that admission to the class is sought solely from an earnest desire to derive all the benefit that can be obtained from the work carried on by its members. It is therefore expected that the members of this new section will work faithfully and adhere strictly to the rules governing the time for sending in answers.

Answers to this first series must be in the hands of the Secretary not later than March 1st.

Please write your name and address at the head of the first page of answers.

Please write your answers on one side of the paper only.

The Secretary will be pleased to hear from any member of the class who does not understand any questions, and will endeavor, to the best of his ability, to help any such inquirer out of his difficulty.

Please address all communications, answers to questions, etc., to Alfred E. Forstall, Secretary, Room 22, 58 William Street, New York City, and put on the envelope your name and address.

January, 1906.

FIRST SERIES OF QUESTIONS—SECTION OF 1909—PRACTICAL CLASS—AMERICAN GAS LIGHT ASSOCIATION.

1. What is coal gas? What is water gas? What is carburetted water gas? What is oil gas? What is the average composition of each kind of gas?

2. What are the properties that must be possessed by a coal to fit it for being used for the manufacture of coal gas?

3. Name the chief impurities in crude coal gas as it leaves the retorts, and give the reasons why they should be removed from the gas before it is distributed.

4. Name the useful by-products or residuals produced in addition to the gas in the manufacture of coal gas. In the manufacture of carburetted water gas.

5. Name the principal pieces of apparatus necessary in a coal gas works, and state briefly the function of each.

6. Name the principal pieces of apparatus necessary in a carburetted water gas works, and state briefly the function of each.

7. What does the ordinary U or syphon gauge indicate, and what is the object of its use in gas works?

8. How does a suction pump "draw" water? Why and how does a hot chimney "draw"?

9. Why is it necessary to provide for draining all mains and pipes through which gas travels, and how is this done?

10. What is the commonly accepted theory as to the cause of the luminosity of the flame produced by burning illuminating gas in a luminous burner?

11. Why is the flame of a Bunsen or atmospheric burner non-luminous?

12. What is common lime and what is the raw material used in its manufacture? What is hydraulic lime and what is the raw material used in its manufacture? What is hydraulic cement and what is the raw material used in the manufacture of natural hydraulic cement?

(Answers to these questions are due March 1, 1906.)

Answers to First Series of Questions—Section of 1909—Practical Class—American Gas Light Association.

1. What is coal gas? What is water gas? What is carburetted water gas? What is oil gas? What is the average composition of each kind of gas?

Ans. Coal gas is the gas resulting from the dry distillation of coal. Water gas is the gas produced when steam is decomposed by contact and union with carbon at a high temperature. It is a non-luminous gas. Carburetted water gas is the gas produced by adding to and mixing with water gas a certain amount of oil gas, the mixture possessing an illuminating value dependent upon the proportions in which the water gas and oil gas are mixed. Oil gas is the gas resulting from the destructive distillation of oil (liquid hydrocarbons.)

The average composition of each kind of gas is as follows, coal gas and carburetted water gas being taken after purification with iron sponge or mass:

		Coal Gas	Water Gas	Carburetted Water Gas
Carbon Dioxide,	CO_2	1.60%	6.30%	2.70%
Oxygen,	O	0.39%	0.50%	0.70%
Heavy Hydrocarbons		4.25%	......	12.80%
Carbon Monoxide,	CO	8.04%	33.60%	30.70%
Hydrogen,	H	47.04%	50.20%	32.40%
Marsh Gas,	CH_4	36.02%	2.70%	13.90%
Higher Paraffins,	$C_n H_{2n+2}$	......	......	2.40%
Benzene Vapor,	$C_6 H_6$	0.50%	......	0.60%
Nitrogen	N	2.16%	6.70%	3.80%
		100.00%	100.00%	100 00%

The composition of oil gas varies very much with the oil used and the temperature at which it is gasified. Two analysis are given below, No. 1 being that of gas made from Scotch shale oil distilled at a comparatively low temperature and No. 2 that of gas made at a high temperature.

	No. 1.	No. 2.
Hydrogen, H	16.85%	12.44%
Unsaturated Hydrocarbons	44.83%	35.65%
Saturated Hydrocarbons		
Ethane, C_2H_6	17.30%	45.37%
Marsh Gas, CH_4	19.00%	
Carbon Dioxide, CO_2	0.63%	0.74%
Oxygen, O	0.24%	2.00%
Nitrogen, N	1.15%	3.20%
Carbon Monoxide, CO	......	.60%
	100.00%	100.00%

(Trustees.)

2. What are the properties that must be possessed by a coal to fit it for being used for the manufacture of coal gas?

Ans. The most valuable coals for use in the manufacture of coal gas are those which contain a small percentage of ash and sulphur, a comparatively large percentage of volatile matter of good illuminating value, and which possesses coking qualities that permit the production of good salable coke amounting to from 55 per cent. to 65 per cent. of the original weight of the coal.

A good Pittsburg coal, which may be taken as the standard gas coal of the United States, will show the following analysis by weight:

Volatile Matter	33%	to	35%
Fixed Carbon	60%	to	55%
Ash	6%	to	4%
Sulphur	0.4%	to	0.6%

Under proper conditions an increase in any direction may compensate for a proportionate decrease in others. Thus, in cannel coals a large yield of rich gas balances a small production of poor coke, while in some bituminous coals an extra amount of sulphur is offset by an increased yield of gas or a harder, better coke. Comparative cheapness of price may also turn the scale in favor of an otherwise inferior local coal. But, under ordinary conditions, a coal fulfilling the requirements given above is the best for general use in coal gas manufacture. (Trustees.)

3. Name the chief impurities in crude coal gas as it leaves the retorts and give the reasons why they should be removed from the gas before it is distributed.

Ans. The chief impurities in crude coal gas as it comes from the retorts are: Tar, ammonia (NH_3), sulphuretted hydrogen (H_2S) and other sulphur compounds, and carbon dioxide (CO_2).

Tar should be removed by special appliances, since it is certain to condense when the gas cools, and unless it is completely and promptly separated from the gas while still hot it will absorb illuminants, thus reducing the candle power of the gas.

Ammonia should be removed on account of its corrosive action on brass and other metals employed in making meters and gas fixtures, on account of its pungent odor and on account of its marketable value.

Sulphuretted hydrogen and other sulphur compounds should be removed because if allowed to remain in the gas they will produce, when burned, sulphurous oxide, the substance formed by the combustion of sulphur, which is irritating to the lungs. Under favorable conditions the combustion of sulphuretted hydrogen may also form minute quantities of sulphuric acid.

Carbon dioxide is only harmful in so far as it reduces the illuminating value of the gas. The question of its removal or non-removal is usually decided by the comparative cost of such removal, and that of the extra enrichment required to overcome the loss of illuminating value. (Trustees.)

4. Name the useful bye-products or residuals produced in addition to the gas in the manufacture of coal gas. In the manufacture of carburretted water gas.

Ans. The useful bye-products or residuals produced in the manufacture of coal gas are: Coke, retort carbon, tar, ammoniacal liquor, spent oxide and spent lime.

When naphtha is used in the manufacture of carburetted water gas the only residual is a small quantity of thin tar, which is of no value except to be burned under the boilers.

When crude oil or gas oil is used, however, a good tar, which in many places commands a ready sale, is formed in larger quantities. (Trustees.)

5. Name the principal pieces of apparatus necessary in a coal gas works, and state briefly the function of each.

Ans. The principal pieces of apparatus necessary in a coal gas works are: Retorts, stand, bridge and dip-pipes, hydraulic main, exhauster, tar extractor or hot scrubber, condensers, washers or scrubbers, purifiers, station-meter and holders.

The retorts are the closed, heated vessels in which the coal is distilled; the stand, bridge and dip-pipes carry the gas from the retorts to the hydraulic main, the liquor in which forms a self-acting seal preventing the return of the gas to the retorts; the exhauster relieves the retorts from the pressure thrown by the weight of the holder and the resistance met with by the gas in passing through the various pieces of apparatus between retorts and holder; the tar extractor removes the heavy tar from the gas while it is still hot; the condensers gradually cool the gas to the proper temperature (about 60° F.); the washers and scrubbers remove the ammonia and part of the sulphuretted hydrogen and carbon dioxide; the purifiers remove the remainder of the sulphuretted hydrogen, some of the other sulphur compounds, and, if lime is used, the carbon dioxide; the station-meter measures the gas as it is made, thus showing the results that are being obtained; and the holders enable the rate of production to be kept constant by storing the excess gas produced during the time of minimum demand to send it out during the time of maximum demand. (Trustees.)

6. Name the principal pieces of apparatus necessary in a carburetted water gas works, and state briefly the function of each.

Ans. The principal pieces of apparatus necessary in a carburetted water gas works are: The generator, carburetter, superheater, wash-box, scrubbers, condensers, relief holder, exhauster, purifiers, station-meter and storage holder.

The generator is the vessel in which water gas (blue gas) is produced by the action of incandescent carbon upon steam;

the carburetter is the vessel in which the oil is vaporized in the presence of the water gas produced in the generator; the superheater is the vessel in which is completed the gasification of the oil begun in the carburetter, with the formation of a fixed oil gas which is mixed with the water gas; the wash-box answers the same purpose as the hydraulic main in a coal gas plant, forming an automatic seal preventing the return of gas to the generating apparatus; the scrubber is a tar extractor and also acts in connection with the condensers in cooling the gas; the relief holder compensates for the intermittent action of the generating apparatus and permits a steady flow of gas through the pieces of apparatus following it; the exhauster draws the gas from the relief holder and forces it through the purifiers and station meter into the storage holder, the functions of these pieces of apparatus being the same as those of the same parts of a coal gas plant. (Trustees.)

7. What does the ordinary U or syphon pressure gauge indicate, and what is the object of its use in gas works?

Ans. The ordinary U or syphon pressure gauge shows the difference between the respective pressures acting on the surface of the liquid in each leg of the gauge. As used in a gas works it indicates the difference between the atmospheric pressure acting on the water in the leg open to the air, and the pressure of the gas acting on the water in the leg in communication with the interior of the pipe, or piece of apparatus, to which it is attached. Therefore, the pressure shown by the U gauge to be existing in any piece of apparatus is not absolute pressure, but merely the difference between the pressure in the apparatus and that of the outside air. This difference in pressure is expressed in terms of the height of the column of water that it will support. When the difference is positive, that is, when the pressure in the apparatus is greater than that of the air, it is called a "pressure." When the difference is negative, that is, when the pressure in the apparatus is less than that of the air, it is called a "vacuum."

The main object of the use of pressure gauges in gas works is to furnish, at any and all times, information as to the

amount of obstruction to the passage of the gas existing in each piece of apparatus as well as to the total amount offered by all of them combined. A proper distribution of pressure gauges among the various pieces of apparatus enables the operator to promptly detect and quickly locate any tendency to blocking up that might lead to serious trouble if it were not detected and corrected. (Trustees.)

8. How does a suction pump "draw" water? Why and how does a hot chimney "draw?"

Ans. A suction pump being provided with a piston and two valves, one in the piston and the other at the point where the suction pipe enters the cylinder, which valves are set in such a manner as to cause water or air to be pushed out of the delivery pipe of the pump and to permit water to enter from the suction pipe into the space below the piston during the up stroke, and also to permit water to travel through the piston from below upwards while preventing any flow of water from the cylinder back into the suction pipe during the down stroke of the piston, such a pump "draws" water by the forcing out from the cylinder of the water, or air, in the space above the piston as this is raised, and thus, by decreasing the amount of water, or air, left to fill the original space, reducing the pressure in the lower part of the cylinder, and in the suction pipe, below that exerted by the atmosphere. The surface of the water outside the suction pipe being, therefore, subjected to a higher pressure than the surface inside this pipe, water is pushed into the pipe and through it into the cylinder of the pump to a height above the outside level dependent upon the amount by which the action of the piston reduces the pressure in the pipe and cylinder below the outside pressure. This pressing up of the water continues as long as the pump is working and delivering water, the space occupied by the water thrown off by each stroke of the piston being filled by water forced in by the excess of pressure on its outer surface. The water is thus moved, not by a pulling force, as is implied by the commonly accepted way of describing the working of a suction pump by saying that it "draws" water, but by a pushing force, each molecule of water being moved along

because the pressure behind it is greater than that in front of it.

In the same way the draft of a chimney is caused by a difference of pressure at the base of the chimney, due to the difference between the weight of the column of hot air and products of combustion in the chimney and that of a column of cold external air, of equal height and cross section. The contents of a chimney being all cold, there is no tendency of the air, or the gas within it, to rise or fall. The contents being heated, either from the warm sides of the chimney, or otherwise, expand. A portion of them, by this act of expansion, is forced out of the chimney; the rest of the contents, being expanded, are lighter, by the weight of the amount forced out, than the surrounding atmosphere, and will be displaced by the heavier air pressing for admission at the base of the chimney. A flow through the chimney is thus established, and will be maintained as long as the pressure of the atmosphere at the base of the chimney is greater than the downward pressure of the contents of the chimney. (Trustees.)

9. Why is it necessary to provide for draining all mains and pipes through which gas travels, and how is this done?

Ans. Gas as it escapes from the retort, or generating apparatus, contains water vapor and condensable hydrocarbon vapors, which are deposited in the form of liquids as the gas cools down during the process of condensation. And even though all the condensable hydrocarbon vapors may have been removed during this process, the contact with the water in the water seals throughout the apparatus, and with that in the holder tanks, makes it certain that the gas entering the street main system will be saturated with water vapor at the temperature it then possesses. When this temperature is reduced, during the passage of the gas through the mains, some of the vapor will be deposited in the pipes in the liquid form, and, unless provision is made for drawing this off as it deposits, the pipes will ultimately fill up and the flow of gas through them will be cut off. It is, therefore, necessary to lay all gas pipes on a slight incline without any sags or traps and to provide means for removing the liquids accumulating at the low points.

When the pipes are above the ground in the works the liquids can usually be run off through constantly flowing syphons, but when the pipes are underground it is necessary to provide drip pots or drips into which the condensed liquids run and from which they are pumped at intervals. (Trustees.)

10. What is the commonly accepted theory as to the cause of the luminosity of the flame produced by burning illuminating gas in a luminous burner?

Ans. The principal cause of the luminosity of the flames produced by burning illuminating gas in ordinary burners is believed to be the heating to incandescence, before they meet with sufficient air for their combustion, of minute particles of solid carbon formed within the flames. It is thought that these carbon particles are produced by the decomposition of the hydrocarbons in the gas which results from their exposure, while in the interior of the flame and out of contact with air, to the heat produced by the combustion, on the surface of the flame, of the hydrogen, marsh gas and carbon monoxide. As the carbon is set free from chemical combination with another element, or as it is called is "nascent" in the flame, the particles are really molecules of carbon many times finer than any particles that can be produced by mechanical subdivision, and therefore are readily heated to incandescence by the heat of the flame and as readily consumed when they come in contact with air.

Under this theory the amount of light given by a flame will depend largely upon the quantity of carbon set free in the flame and upon the temperature to which the particles of carbon are heated before they are consumed. In practice it is found that the greatest illuminating value per cubic foot of gas is given by flames when they are just on the point of smoking, and also that anything which tends to raise the temperature of the flame increases the light given, other things being equal.

It will be noticed that the presence of carbon particles is spoken of as the principal, but not the sole, cause of luminosity in the flames produced by the combustion of illuminating gas. This is because a portion of the light yielded by such

flames is derived from the combustion, at the high temperatures existing in them, of marsh gas and of some of the heavier hydrocarbons before they are decomposed. An increase in the temperature of a flame increases the amount of light produced in this way as well as that derived from the incandescence of the carbon particles.

Quite a full discussion of the facts and reasoning upon which the solid particle theory of the luminosity of illuminating gas flames is based will be found in the first of a series of lectures upon Gaseous Illuminants delivered by Prof. V. B. Lewes, and published in the American Gas Light Journal, Vol. LIII, page 877, and in the Journal of Gas Lighting, Etc., Vol. LVI, page 1140. (Trustees.)

11. Why is the flame of a Bunsen or atmospheric burner non-luminous?

Ans. The flame of a Bunsen or atmospheric burner is non-luminous because such a flame contains none of the carbon particles, the raising of which to incandescence furnishes the greater part of the light produced by a luminous flame as is explained in the answer to Question No. 10. The absence of carbon particles from the atmospheric flame is considered to be due to the chemical activity of the oxygen mixed with the gas before combustion in burning up the hydrocarbons before they can be decomposed; to the diluting effect of the nitrogen which raises the temperature that must be reached before the hydrocarbons decompose; and also to the cooling effect of the air which acts in the same way as the diluting effect and adds to the general result, although when the proportion of air to gas is high, above 3 to 1, the cooling is less than the increase in temperature due to more rapid oxidation. "In an ordinary atmospheric flame the nitrogen and oxygen are of about equal importance in bringing about the loss of luminosity, but if the quantity of air be increased the oxidation becomes the principal factor and the nitrogen practically ceases to exert any influence." (Trustees.)

12. What is common lime and what is the raw material used in its manufacture? What is hydraulic lime and what is

the raw material used in its manufacture? What is hydraulic cement and what is the raw material used in the manufacture of natural hydraulic cement?

Ans. Common lime is the substance resulting from the calcination of pure or nearly pure limestone, such as marble, chalk, etc., at a high temperature applied for a sufficient length of time to drive off the carbon dioxide (CO_2) in the limestone. It is principally calcic oxide (CaO) with from 3% to 10% of impurities such as silica, alumina, magnesia, oxide of manganese, and traces of the alkalies. It is highly caustic with a strong affinity for water, rapidly absorbing nearly one-quarter of its own weight of this substance when brought into contact with it. This absorption produces a great elevation of temperature accompanied by an increase to from 2½ to 3 times the original volume and the reduction of the lime to an impalpable powder [slaked lime or calcic hydrate $Ca(OH_2)$] which forms with water an unctuous paste. The paste, in common with mortar made from it, will not harden when kept under water, in damp places or out of contact with air.

Hydraulic lime is the lime made by calcining limestones containing a larger percentage of impurities than those from which common lime is obtained. If the limestone contains from 10% to 20% of clay mixed with carbonate of lime, the lime produced is said to be argillaceous, while if the limestone contains from 12% to 18% of silica, the lime produced is said to be silicious. Hydraulic lime will slake and its paste, or a mortar made from it, will harden under water and in damp places. No hydraulic lime is manufactured in the United States.

Hydraulic cement is the substance obtained by calcining a mixture of clay and carbonate of lime in the proper proportions at a high, long continued heat and then reducing the lumps produced by this calcination to a fine powder by grinding them between millstones. A paste or mortar made from hydraulic cement has the property of setting or hardening under water or in damp, moist places, and increases in strength as it increases in age.

Natural hydraulic cement is made by calcining and grinding

limestones, which contain approximately the proper proportions of clay and lime, that is, from 20% to 22% of clay, and from 78% to 80% of carbonate of lime ($CaCO_3$). (Trustees.)

Fifth Series of Questions—Section of 1908—Practical Class—American Gas Light Association.

1. Give the meaning of the terms "run of mine," "¾ inch," and "1½ inch," as applied to bituminous coal, and state, with your reasons for the statement, which class of coal gives the best carbonizing results.

2. Describe the putting into operation of a new bench of retorts with either a full depth or a half-depth regenerative setting, from the lighting of the fire to the putting in of the first charge, giving the precautions to be taken to prevent injury to the setting.

3. The dip-pipe on the take-off from the superheater into the washbox of a double superheater carburetted water gas apparatus has an internal diameter of 8″ and an external diameter of 9¼″ and has a seal of 2½″. The internal diameter of the washbox is 4′0″. The drain-pipes from the scrubber and condenser are carried down below the surface of the liquor in the seal pot to a depth of 3′6″. Two sets are in operation. An obstruction occurs in the pipe taking the gas from the condensers while one set is making gas and the other is under blast. Will the gas show first at the scrubber and condenser seals or at the top of the superheater of the latter set? Give the reasoning and calculations by which your answer is reached.

4. In a coal gas apparatus what is a "washer"? What is a "scrubber"?

5. What would you do with quicklime to prepare it for the purifiers?

6. What action takes place between "oxide of iron" and sulphuretted hydrogen in the purifiers? What change occurs in the mass when exposed to the atmosphere, after use in the boxes? Give a general answer, and then give the chemistry of the operations as far as you can.

7. The inner section of a two-lift gas holder has a diameter of 88′ and a height of 20′, and the outer section has the same height and a diameter of 90′. The cup is 16″ deep. The holder is contained in a brick tank 92′ in diameter and 21′ deep from water line to bottom. In the tank is a "cone" which has a height of 15′, a diameter of 29′ at the top and one of 82′ at the bottom. How many gallons of water will be required to fill the tank to the water line, and what will be the working capacity of the holder in cubic feet? Give your calculations.

8. What is a heat unit? What is the value of a British thermal unit and of a calorie?

9. How often, when, and in what manner would you inspect house piping to insure tightness. Give your reasons.

10. Give a description, illustrated with sketches, of a Welsbach gas burner, and state how you would adjust air and gas so as to get the greatest amount of light with the proper consumption.

11. What causes an atmospheric burner to "light back," and to what is due the odor given off when this occurs?

12. In what part of the masonry or brick work of a gas works would you use cement mortar instead of lime mortar, and why?

(Answers to these questions are due March 20, 1906.)

Answers to Fifth Series of Questions—Section of 1908—Practical Class—American Gas Light Association.

The answer to Question No. 2 is included among the answers to the Seventh Series of Questions for the Section of 1907, and can be found on page 82 of this volume; the answer to Question No. 5 is included among the Answers to the Eighth Series of Questions for the Section of 1907, and can be found on page 160.

The answers to the other questions are as follows:

1. Give the meaning of the terms "run of mine," "¾-inch" and "1½-inch" as applied to bituminous coal, and state, with your reasons for the statement, which class of coal gives the best carbonizing results.

Ans. "Run of mine" coal is coal which is shipped from the mine in the condition in which it is mined and loaded into the mine cars, being run from these cars directly into the railroad cars, or the boats, as the case may be, without being screened. It consists therefore of a mixture of lumps of all sizes with slack or dust.

"¾-inch" coal is coal that has been passed over a ¾-inch screen before being loaded into the railroad car, or the boat, and has therefore been freed from the slack and dust as well as from the smaller pieces of coal that pass through the screen.

"1½-inch" coal is coal that has been passed over a 1½-inch screen and is therefore still more free from small pieces than is ¾-inch coal.

The screens used at the tipples of the coal mines are, as a rule, not made with meshes, but are formed by parallel bars of iron running the long way of the screen. In a ¾-inch screen the bars have a clear space ¾-inch wide between them, and in a 1½-inch screen the clear space is 1½ inches wide. The openings in the screens are long narrow slits, through which will pass not only the small cubes but also long pieces of small cross-section.

The screened coal gives better carbonizing results than the "run of mine," since the latter is not only harder to burn off,

owing to the dust contained in it, which forms in the retort a compact mass through which the heat can only penetrate slowly and with difficulty, but also contains more dirt and slate and a larger percentage of sulphur and will not yield as much gas per pound, or as clean gas, even when carefully and thoroughly carbonized. The majority of companies manufacturing coal gas buy ¾-inch coal, it being thought that as long as the slack is screened out there is no practical difference in value between the small lumps and the larger ones. However, at least one large company uses 1½-inch coal, and the engineer of this company considers that the results obtained from it are enough better than those obtained from ¾-inch coal to more than compensate for the higher price charged for it. (Trustees.)

3. The dip-pipe on the take-off from the superheater into the washbox of a double superheater carburetted water gas apparatus has an internal diameter of 8″ and an external diameter of 9¼″ and has a seal of 2½″. The internal diameter of the washbox is 4′ 0″. The drain pipes from the scrubber and condenser are carried down below the surface of the liquor in the seal pot to a depth of 3′ 6″. Two sets are in operation. An obstruction occurs in the pipe taking the gas from the condensers while one set is making gas and the other is under blast. Will the gas show first at the scrubber and condenser seals or at the top of the superheater of the latter set? Give the reasoning and calculations by which your answer is reached.

Ans. The gas will show first at the opening through which it can pass with the least resistance, and it is therefore necessary to determine the resistance offered by the washbox to the backward passage of gas and compare it with that offered by the depth of seal on the drain pipes.

Before any gas can pass backward through the washbox, the level of the water in the portion outside of the dip-pipe must be depressed below the lower edge of this pipe, the water displaced being forced into the dip-pipe. The pressure required to depress the level outside and raise that inside will be equal to the height, above the lower edge of the dip-pipe,

to which the water will have risen in the dip and take-off pipe when the outside level is just even with this edge. This height will be equal to the height at which the water, on the inside, stands above the edge when the pressures are equal inside and out, plus the quotient obtained by dividing the volume of water that has to be forced from the outside to the inside by the area of the pipe. The above volume of water is equal to the area of the space in the washbox outside the dip-pipe multiplied by the depth of the seal.

In the case given, as the diameter of the washbox is 4′ 0″ or 48″, and its area is 1809.6 square inches, while the outside diameter of the dip-pipe is 9¼″ and its area is 67.2 square inches, the area of the space outside the pipes is $1809.6 - 67.2 = 1742.4$ square inches. The depth of seal is 2½″ and therefore the volume of water to be displaced is $1742.4 \times 2.5 = 4356$ cubic inches. The internal diameter of the dip-pipe is 8″ and the internal area 50.27 square inches, hence the displaced water will fill the dip-pipe to a height of $\frac{4356}{50.27} = 86.6''$. The dip pipe being sealed to a depth of 2½″, the water will stand in it to that height when the pressure inside and outside are equal, and, therefore the total height to which the water will have to be raised on the inside, before the bottom edge of the pipe will be left uncovered on the outside will be $86.6'' + 2.5'' = 89.1''$.

Since the drain-pipes from the condenser and scrubber are sealed to a depth of 3′ 6″, or 42″ only, gas will escape through them before it shows at the top of the superheater, and will escape through the latter opening only in case the blowing of the seal on the drain-pipes does not afford sufficient relief to keep the pressure to 89″. (Trustees.)

4. In a coal gas apparatus what is a "washer"? What is a "scrubber"?

Ans. The washer is a vessel so constructed that the gas passing through it is made to bubble through water. The scrubber is a vessel in which the gas comes in contact with wetted surfaces. These surfaces may be stationary, and be kept wetted by a spray of water thrown over them; or they may, as in the so-called "mechanical scrubber," revolve

around a central shaft, dipping in their passage into water, and rising from the water wetted, to come in contact with the passing gas. In a coal gas apparatus the washer is employed to remove ammonia, sulphur compounds, carbon dioxide, and whatever of tar may be in the gas at the time it reaches the washer, while the scrubber is employed only for the removal of ammonia, sulphur compounds and carbon dioxide. (Trustees.)

6. What action takes place between "oxide of iron" and sulphuretted hydrogen in the purifiers? What change occurs in the mass when exposed to the atmosphere, after use in the boxes? Give a general answer, and then give the chemistry of the operations as far as you can.

Ans. When the sulphuretted hydrogen in the gas comes in contact with the hydrated ferric oxide or sesqui-oxide of iron, in the purifiers, the sulphur of the former unites with the iron and forms iron sulphide, and the hydrogen unites with the oxygen and forms water. At the same time part of the sulphur of the sulphuretted hydrogen is liberated in a free state.

The probable chemical changes are shown by the equations:

$$Fe_2O_3.\ H_2O+3H_2S=Fe_2S_3+4H_2O \text{ and}$$
$$2Fe_2O_3.\ H_2O+6H_2S=4FeS+S_2+8H_2O.$$

It is supposed that from 17% to 30% of the sulphuretted hydrogen absorbed by the oxide is absorbed according to the second equation and the rest according to the first equation.

After the mass has been fouled it is exposed to the air. The iron of the iron sulphide unites with the oxygen of the air, and with the water that is present in the shape of moisture in the mass and in the atmosphere, and again forms ferric oxide, the sulphur being liberated in the free state.

Omitting the moisture, the probable chemical changes are shown by these equations:

$$2Fe_2S_3+3O_2=2Fe_2O_3+3S_2$$
$$12FeS+9O_2=6Fe_2O_3+6S_2$$

After several revivifications the free sulphur in the mass

takes up a small amount of bisulphide of carbon, probably by direct solution. (Trustees.)

7. The inner section of a two-lift gas holder has a diameter of 88′ and a height of 20′, and the outer section has the same height and a diameter of 90′. The cup is 16″ deep. The holder is contained in a brick tank 92′ in diameter and 21′ deep from water line to bottom. In the tank is a "cone" which has a height of 15′, a diameter of 29′ at the top and one of 82′ at the bottom. How many gallons of water will be required to fill the tank to the water line, and what will be the working capacity of the holder in cubic feet? Give your calculations.

Ans. The volume of the space in the holder tank which will be occupied by water is equal to the difference between the volume of a cylinder, having a diameter equal to that of the tank and a height equal to the height of the tank from the bottom up to the water line, and the volume of a frustrum of a cone to the dimensions of the "cone" in the tank. The volume of a cylinder is equal to the product obtained by multiplying the area of the base by the height. A circle 92′ in diameter has an area of 6647.6 square feet. The distance from the bottom of the tank to the water line is 21′, so the volume of the cylinder formed by the tank is $6647.6 \times 21 = 139{,}599.6$ cubic feet. The volume of a frustrum of a cone is equal to the product obtained by multiplying the sum of the areas of the two bases and of a mean proportional between these two bases by one-third the altitude. In this particular case the lower base of the cone has a diameter of 82′ and an area of 5,281 square feet, and the upper base has a diameter of 29′ and an area of 660.5 square feet. The mean proportional between these areas is therefore $\sqrt{660.5 \times 5281} = 1867.6$, and the sum of the two areas and this mean proportional is 7809.1 square feet. The altitude of the frustrum is 15′, hence the volume is $7809.1 \times 5 = 39{,}045.5$ cubic feet. To fill the tank to the water line will require $139{,}599.6 - 39{,}045.5 = 100554.1$ cubic feet, or $100554.1 \times 7.48 = 752{,}144$ gallons of water.

The working capacity of the holder will be equal to the volume of the cylindrical portion of the inner section, the gas in the space under the crown above this cylindrical portion not being available for use, plus the volume of that portion of the outer section that is not lapped by the inner section, nor required to be kept below the water level in order to avoid any danger of the gas blowing out from under the bottom curb. The cup being 16″ deep, and safety requiring that the bottom of the outer section should always be kept 12″ below the water level, the working height of the outer section will be 2′ 4″, or 2.33′ less than its total height. The total height being 20′, the working height is 17.67′. The diameter of the inner section being 88′, the volume is equal to 6082.1 (the area of a circle 88′ in diameter) $\times$ 20 = 121,642 cubic feet. The diameter of the outer section being 90′, the working volume of this section is equal to 6361.7 (the area of a circle 90′ in diameter) $\times$ 17.67 = 112,411 cubic feet. The working capacity of the holder is therefore 234,053 cubic feet. (Trustees.)

8. What is a heat unit? What is the value of a British Thermal Unit and of a calorie?

Ans. In order to be able to express different quantities of heat in comparable terms, it is necessary to have some standard or unit of quantity by which to measure these quantities. Such a standard or unit is called a heat unit.

The British Thermal Unit (B. t. u.), the heat unit most largely used by English speaking nations, is the amount of heat required to raise the temperature of one avoirdupois pound of pure water one Fahrenheit degree from the temperature of maximum density of water, which is 39.1 degrees Fahrenheit. The variation in the quantity of heat necessary to raise the temperature of a pound of water one degree is so slight for any temperature between 32° and 212°, that in general the British Thermal Unit may be safely taken as the amount of heat necessary to raise the temperature of one pound avoirdupois of pure water one degree Fahrenheit. Thus we may say that to raise the temperature of 30 pounds of water from 40° to 60° Fahrenheit requires 600 British

Thermal Units; for we have raised the temperature of 30 pounds of water 20°, and to raise the temperature of 30 pounds of water one degree requires 30 British Thermal Units, and to raise the temperature of the same quantity 20 degrees requires 20 times as much, or 600 British Thermal Units.

A calorie, the heat unit used in connection with the metric system of weights and measures, is the amount of heat required to raise the temperature of one kilogramme of water one degree centigrade from the temperature of water at its maximum density, or about 4° C. For the reason stated above, the calorie may, in ordinary work, be taken to be the amount of heat required to raise, by one degree centigrade, the temperature of a kilogramme of water at any temperature between 0° C. and 100° C. Since a kilogramme equals 2.204 pounds and a degree centigrade equals 1.8 degrees Fahrenheit, a calorie equals $2.204 \times 1.8 = 3.968$ B. t. u. (Trustees.)

9. How often, when, and in what manner would you inspect house piping to insure tightness? Give your reasons.

Ans. When the piping has been completed and before it is covered up by plastering and flooring, for the purpose of seeing that it is of the proper size and so that if any leaks exist, they may be discovered while it is comparatively easy to repair them. After the plastering and flooring have been put in, for the purpose of detecting any damage to the pipes that may have been caused by this work. When any additions or alterations have been made, to see whether the new work is tight.

The Sanitary Engineer and Building Record gives the following clear directions:

"If the house is in progress of construction, see that all the outlets are carefully closed with caps, and that the foot of the rising line is stopped. Then at any convenient side light attach the ordinary gas-fitters' pump, which is simply an air pump. To the same side light, or an adjacent one, attach the mercury column gauge used by gas-fitters with a column from fifteen to twenty inches in length. Great care must be now taken to prove that there are no leaks in the gauge or its connection or cock, and in the pump and hose connections, and

a good cock should be used between the permanent gas-pipe and any temporary connections to pump, so that it may be closed immediately after the pumping stops, to prevent back leakage of air through the pump valves or hose joints.

"When all is complete, pump the pipe system in the house full of air until the mercury rises at least twelve inches. Then close the intermediate cock before mentioned, and should the mercury column be found to 'stand' for five minutes, it is reasonable to assume that the pipes are sufficiently air and gas tight for any pressure they can afterwards be subjected to.

"Should there prove to be a very large leak, it will be apparent at once, as it will be impossible to get a pressure worth considering, the mercury simply bobbing up and down in the tube.

"It may be an outlet that has been neglected to be closed, or it may be a long split in the pipe. If the former, and very close to the pump, the mercury will not respond; but should it be far away, with considerable length of pipe to cause resistance, the mercury will jump and return as suddenly. But should there be a split pipe or an aggregation of small leaks, the mercury will run back steadily, though slower than it rises, between the strokes of the pump. Should it rise well in the glass and sink at the rate of about one inch in five seconds, small leaks only in fittings or joints may then be anticipated. Of course there are exceptions to these rules, which are only for general guidance.

"To locate a leak, then, that cannot be heard blowing, strong soap water applied with a brush or sponge may be used. The liquid is rubbed over suspected joints or fittings, and air bubbles are blown by the escaping air.

"Sometimes it becomes necessary to use ether in the pipes in locating leaks, if the pipes are under floors or in partitions. The ether is put into a bend of the hose or into a cup attached to the pipe and blown into the pipes with the air. By following the lines of the pipes the approximate position of a leak may then be determined by the odor of escaping ether.

"In very large work it is well to prove a floor at a time, and when all are done, connect them with the riser and prove as a whole.

"If the house is an old one, or has been finished, and you have to test for leaks, take off the meter and cap the bottom of the riser; also unhang the gas fixtures and remove the brackets and cap all outlets carefully. Then use ether and locate leaks before tearing up floors or breaking plaster.

"Occasionally, when a gas fitter cannot get a job tight, there is a possibility he may cut off the part or floor of the building he cannot get sufficiently tight to suit the inspector's idea of perfection. The inspector can only prove such practice by removing or slacking off a cap here or there about the house if he suspect such an attempt. If no air escapes, then he has the dead end."

Whenever a meter is set the piping should be tested by closing all outlets on the piping, and turning gas into the meter. A movement of the test hand indicate a leak.. (Trustees.)

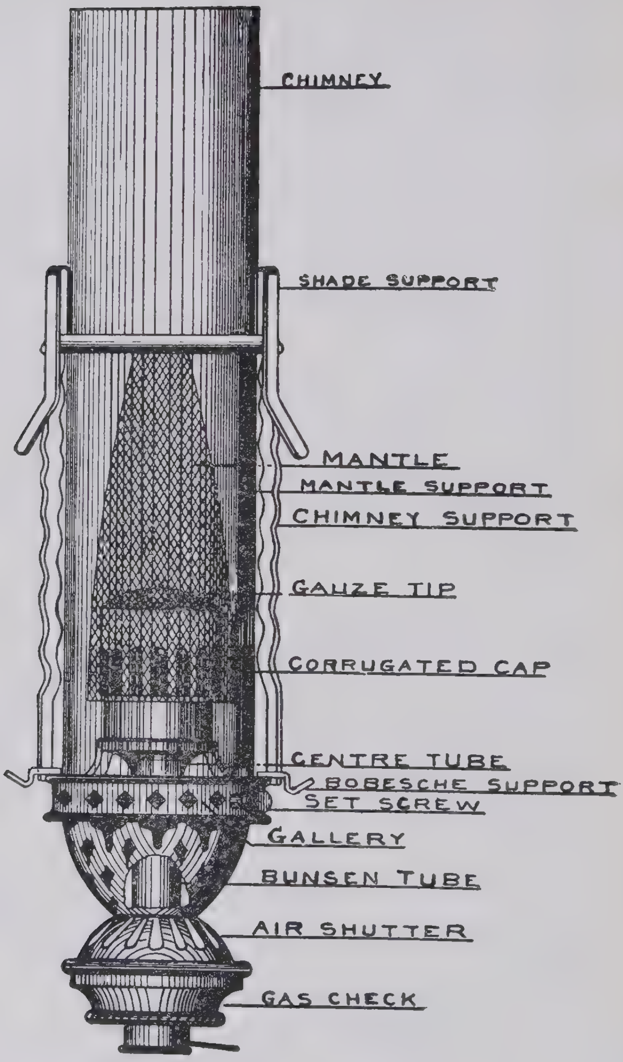
10. Give a description, illustrated with sketches, of a Welsbach gas burner, and state how you would adjust air and gas so as to get the greatest amount of light with the proper consumption.

Ans. The Welsbach burner belongs to that class of lighting devices commonly known as Incandescent Gas Burners, in distinction from the Open Tip or Open Flame Burners, and is a burner in which the source of light is not one of the component parts of the gas itself, heated to incandescence by another part of the gas, but is a foreign body introduced into the flame (which is perfectly non-luminous) and heated till it glows.

"The Welsbach burner consists primarily of a Bunsen burner and a mantle; the gallery, air-shutter, chimney, etc., being added to give it practical value for general lighting purposes.

"The mantle is made by saturating a web of cotton thread in a fluid holding in solution salts of the rare earths, thorium and cerium. It is given the proper shape by stretching over wooden forms and is sewed at the top to the support with platinum wire. The cotton is then burned out, leaving an exact reproduction of the web by the oxides of the earths.

"Referring now to the cut and taking up the parts in order



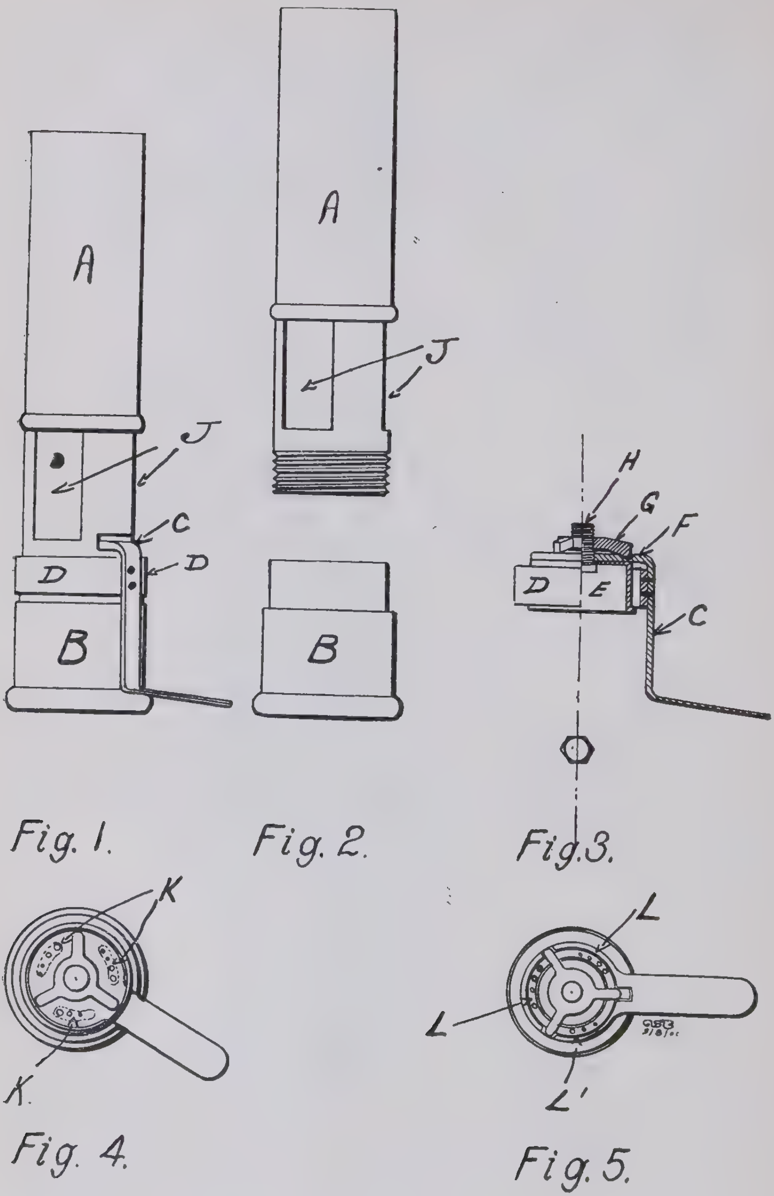
WELSBACH BURNER

we find first the Bunsen tube which screws on to the gas fixture. This can be divided into three parts, the base, the check and the tube proper. The check is held in the base by the tube screwing down on it and is made in different forms. One consists of a flat piece of brass in which are three small holes. These holes are of different sizes for different pressures of the gas supply, those for a two-inch pressure being smaller than those for a one-inch pressure, the object being to keep the amount of gas supplied to the burner as near three feet an hour as possible. This form of check can only be adjusted to one particular pressure and will not give as good results at any other pressure. In case of very high pressures a check with one hole is sometimes used. This check is not flat, but is slightly coned with the hole at the apex.

"The form of check now in general use is that known as the 'adjustable' check, which has the advantage of being readily adjustable to any pressure within the limits ordinarily met with in practice, thus enabling the same check to be used under varying pressures. The Bunsen tube with adjustable check is fully illustrated in the second cut.

"Figure 1 shows the Bunsen tube complete; Figure 2 shows the upper part of the tube, A, unscrewed from the lower part of the tube, B, and with the adjustable parts removed. The assembled adjustable parts, which can be lifted out of the base of the tube, are shown in Figure 3. Figure 4 is a plan of the complete tube, and Figure 5 is a plan of the adjustable parts.

"In detail, the adjustable parts consist of a thimble, E, perforated on the top with three circumferential slots, K, K, K, Figure 4. On top of this thimble is a plate, F, one side of which is extended to form a handle, C. This plate, F, is perforated with 11 holes, arranged in groups of 4, 4, and 3, as shown in Figure 5 at L, L, and L[1]. There are three sizes of holes, and one hole is omitted from one of the groups, so that gas will be admitted through but two holes, when necessary, as in cases where high pressure is met with. This plate, F, makes a gas-tight joint with the thimble, E, being held down to the latter by means of a spider, G, and screw, H, Figure 3. A ring, D, is riveted to the lever, as in Figures 1 and 3.



Details of Bunsen with Adjustable Check.

"If the pressure is high, the lever is turned clock-wise to its extreme position. In this case the slots in the thimble are entirely shut off with the exception of but 2 holes in the plate. If the pressure is low, the lever is moved counter-clock-wise, so that more holes are uncovered ; and the extreme position allows gas to pass through the three sets of holes, as shown in Figure 4.

"The office of the air-shutter is to regulate the supply of air admitted to the tube for mixture with the gas to make the Bunsen flame. If the gas is rich, more oxygen is necessary for complete combustion than if it is poor, and the air-shutter must be opened wider in order that more air will be admitted.

"The gallery carries the mantle, shades and chimney. The mantle is mounted so that the lower part surrounds the cap, and is put in place by carefully lowering the support into the lug (not shown in the print), and tightening up the set screw.

"The central tube which fits over the Bunsen tube is a part of the gallery, and holds it in the proper position. It is enlarged at the top to a mixing chamber on which is placed the gauze held by the cap. This gauze assists in the mixture of the air and gas, and also prevents the flame flashing back.

"The frame of the gallery answers two purposes, it carries the shades and protects the mantle when the chimney is being taken off or put on. The shade-supports slip over the ends of the wires forming the frame and carry certain styles of shades ; when other shades are used they can be taken off.

"The bobesche-supports hold the bobesche or eye-screen, a small bowl-shaped shade which is used with the dome shade when the light is at such a height that the direct rays from the mantle are disagreeable.

"The chimney may be of glass or mica, the latter being preferable in situations exposed to draughts.

"The above is a description of the type of burner in general use. There are modifications of it for special cases, but they differ only in construction and not in principle."

The proper adjustment of air and gas is obtained as follows: Set the air-shutter so that the openings are about half open. Light the gas and see if any flame shows above the top of the mantle. If it does, turn the check lever clock-wise until the

flame disappears. If no flame shows, turn lever anti-clock-wise until flame appears, then turn lever back until the flame disappears as above. Now move air-shutter slowly back and forth, watching the illumination given by the burner on a sheet of white paper placed underneath it, until the point of maximum illumination is found. With the adjustments so made, the greatest possible amount of light is being attained from the burner.

Excess of gas can always be detected by the appearance of a tip of flame above the top of the mantle, the hand being held so as to shade the eyes. Deficiency of gas shows by the decrease in light, as will also a large excess of gas. Excess of air will be shown by the flickering of the light; deficiency of air by the blackening of the mantle in the absence of an excess of gas. (Trustees.)

11. What causes an atmospheric burner to "light back," and to what is due the odor given off when this occurs?

Ans. An atmospheric burner "lights back" whenever the speed with which the mixture of air and gas travels through the tube is slower than that at which a flame can spread through the mixture. Anything which decreases the rate of flow of the mixture of air and gas, or which increases the speed at which the flame can spread, will, therefore, tend to produce "lighting back."

Some of the causes of a slow speed of the air and gas mixture are a large tube area, the issuing of the gas from the gas orifice at a low velocity because of being under a low pressure, and any draught or concussion of the air that creates a pressure at the point of ignition. The rapidity with which the flame can be propagated back through the mixture, depends upon the proportion in which air and gas are present, being greater the more nearly the amount of air present approaches to that required for the complete combustion of the gas. "Lighting back" may, therefore, be brought about by the gas being at too low a pressure, by a draught, or a sudden wave of air, such as that produced by the violent closing of a door, or by poor design in the burner, either in the way of providing too

large a tube, or of permitting the drawing in of too much air for the amount of gas used.

When "lighting back" occurs the gas burns as it issues from the gas orifice without being previously mixed with air, and consequently a luminous flame is produced. The conditions under which this flame burns are extremely unfavorable for the attainment of the complete combustion of the gas, because, not only is the access of air to the flame extremely restricted, but the flame is also surrounded by cold surfaces, and is extinguished by contact with them before complete combustion can take place. The combustion has, however, proceeded to a point at which the decomposition of the hydrocarbons has begun, and as one of the first steps in this decomposition is the formation of acetylene, C_2H_2, the products of the arrested combustion contain an appreciable percentage of acetylene, and it is to this gas that is due the distinctive odor noticed whenever an atmospheric flame is allowed to burn after having "lighted back." The products of this arrested combustion also contain carbon monoxide, and are, therefore, poisonous. (Trustees.)

12. In what part of the masonry or brick work of a gas works would you use cement mortar instead of lime mortar, and why?

Ans. Cement mortar should be used in all thick walls, in all masonry subject to vibration, and in masonry exposed to water or moisture. It should, therefore, be used in the foundations of buildings and machinery, and in holder tank walls. Unlike lime mortar, good cement mortar increases in strength with age even under water or exposed to moisture—exposure to which will disintegrate lime mortar rapidly.

When cement is cheap it is a question whether it could not profitably be substituted for lime in the mortar for even ordinary masonry. Its cost for such purpose when great strength is not required may be reduced without serious loss of strength by the addition to the mortar of from 20% to 25% of lime paste. (Trustees.)

Ninth Series of Questions—Section of 1907—Practical Class—American Gas Light Association.

1. When using gas oil as the carburetting material in a double superheater carburetted water gas apparatus, should the checker bricks be kept at the same temperature in both the carburetter and superheater? If not, in which vessel should the highest heat be carried? Give the reasons for your answer.

2. It is desired to "let down" a bench of coal gas retorts heated by a regenerative furnace. What is to be done in order that the bench may, with safety, be cooled down and kept idle until the increasing demand for gas, or other reason, shall make it important to again fire it up? No repairs are to be made to the bench.

3. Give a description, illustrated with sketches, of some form of furnace for horizontal tubular boilers adapted to give a good evaporation per pound of gas coke.

4. Give a drawing showing, by a section through the centre lines of the bent pipes, the layout for the bells on the mouthpieces and for the bent pipes for a bench containing six retorts, of the cross section given on the cut accompanying the answer to Question No. 2, Second Series, set in two vertical rows of three each, the centres of the retorts in each row being 2′ 3″ from the centre line of the bench and 2′ 0″ apart vertically. The pipes are to be 7″ in diameter. The hydraulic main is 9′ 9¾″ long over all and has a 3″ angle iron at each end, the space between these angles being 9′ 3¾″. The drawing must be fully dimensioned. Give also a written explanation of your reasons for adopting the design shown.

5. A boiler using a fuel with a calorific value of 13,800 B. t. u. per pound is shown by a test to be evaporating 8.5 pounds of water per pound of fuel used. The water is fed to the boiler at a temperature of 15° F. and the

gauge pressure is 95 pounds. What is the efficiency of the boiler? Give your calculations.

6. Describe some method of making iron oxide to be used for the removal of sulphuretted hydrogen from gas during its purification.

7. How would you make quantitative tests for carbonic acid and sulphuretted hydrogen in gas? How much by volume of each would you expect to find in coal gas and in carburetted water gas at the inlet to the purifiers?

8. If you had a set of purifiers consisting of four $12' \times 14' \times 4'$ boxes in which you wished to use oxide of iron in one layer $3'\ 0''$ deep in each box, how many bushels of oxide would you buy, or make up? The amount given should include not only the oxide actually in the boxes at any one time but also that which it would be necessary to have on the floor at the same time, to make it certain that each lot of oxide would be afforded the opportunity for complete revivification. Give the reasons for your answer.

9. How does the calorific value of gas affect the consumption per horse power in a gas engine and what do you consider a fair average rate of consumption per brake horse power for a 10-horse engine using a gas having a net calorific value of 600 B. t. u. per cubic foot?

10. If you were sent to a house to investigate a complaint of "poor gas" how would you proceed to determine the cause of the trouble?

11. An instantaneous water heater burning gas at the rate of 75 cubic feet per hour will heat water from a temperature of 50° F. to one of 117° F. at the rate of 68 gallons per hour. The gas has a net calorific value of 620 B.t.u. per cubic foot. What is the efficiency of the heater?

12. Describe the proper method of laying brick in holder tank work.

(Answers to these questions are due April 23, 1906.)

Answers to Ninth Series of Questions—Section of 1907—Practical Class—American Gas Light Association.

1. When using gas oil as the carburetting material in a double superheater carburetted water gas apparatus, should the checker bricks be kept at the same temperature in both the carburetter and superheater? If not, in which vessel should the highest heat be carried? Give the reasons for your answer.

Ans. Under ordinary conditions, the best oil efficiencies are obtained by carrying the checker bricks in the carburetter at a higher heat than those in the superheater.

The reason for this is that a high initial heat seems to be required for evaporating the oil and breaking it up into permanent gases, while these gases, after their formation, should pass as soon as possible into a somewhat lower temperature, since the heavy hydrocarbons or illuminants will be deteriorated by further breaking down if they are subjected to too long an exposure to the high temperatures at which the oil is best broken up. (Trustees.)

2. It is desired to "let down" a bench of coal gas retorts heated by a generative furnace. What is to be done in order that the bench may, with safety, be cooled down and kept idle until the increasing demand for gas, or other reasons, shall make it important to again fire it up? No repairs are to be made to the bench.

Ans. In letting down a bench of retorts with full depth regenerative setting, the last charge should be made as large as the retorts will hold. That is, if the charges are of four hours' duration and the bench is to be let down at 7 o'clock, the charges from 3 o'clock on should be made to almost fill the retorts. The coke from these charges must not be drawn until the bench is cold. The furnace should be left half full of coke. When the last charge is put in, the primary air-slides should be shut down to within ½″ of being closed, secondary air shut off entirely and the dampers closed until there is just sufficient opening left to maintain a slight draft

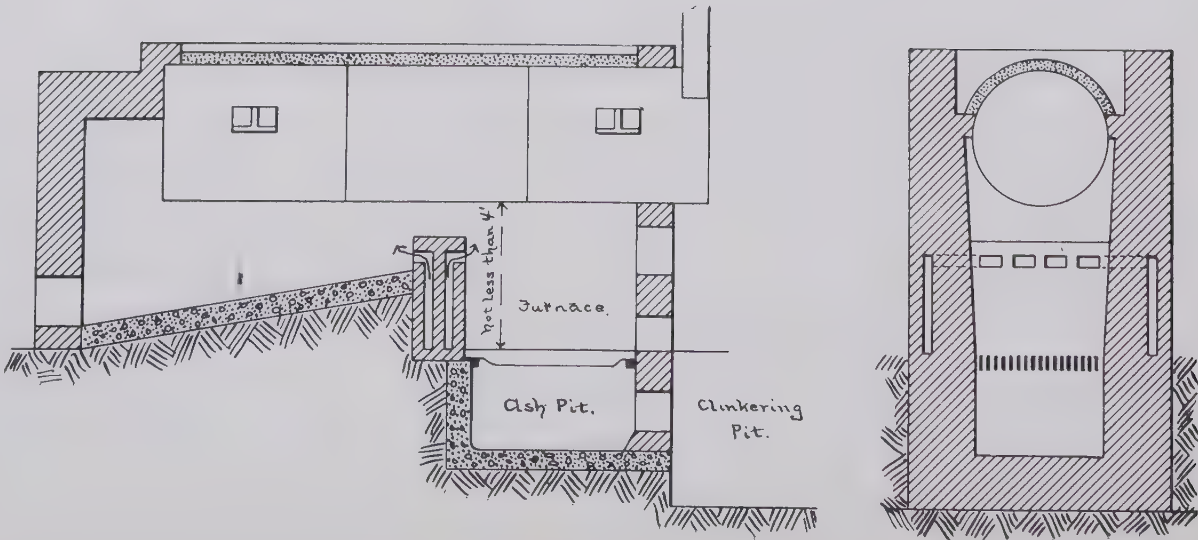
in the furnace. Two or three hours after the last charge is put in, the primary air ports should be closed entirely, all cracks around the brick work plastered up, so as to prevent the entrance of any air into the setting, the opening around the furnace charging door filled with coke dust or ashes to prevent any influx of air at that point, and the dampers practically closed, leaving them just cracked, so as to take off what little gas is still being generated in the furnace, but not open enough to cause any draft through the bench. After the gas is all driven out of the coal in the retorts, the bridge-pipe covers should be raised, so that in case there is any leakage of gas up the dip-pipes through excess of pressure in the hydraulic main, it will escape through the open bridge-pipes instead of working down into the retorts and forming an explosive mixture which might be fired and damage the bench. After all these precautions have been taken, the bench must be allowed to cool down thoroughly, which it will do very slowly, before anything about it is opened for examination or for cleaning the furnace. If handled in this way, the cooling of the setting will be so gradual as not to cause any avoidable injury to retorts or blocks. (Trustees.)

3. Give a description, illustrated with sketches, of some form of furnace for horizontal tubular boilers adapted to give a good evaporation per pound of gas coke.

Ans. The boiler furnace illustrated on the accompanying cut is one that was designed and is used by a gas company which also operates the electric light and power plant in its city. When burning coke in the ordinary boiler furnace in the electric light plant it was found that a comparatively low evaporative efficiency was obtained from it, especially when the boilers were being worked at nearly their rated capacity. The reason for this seemed to be that, owing to the open character of a coke fire, a considerable excess of air was drawn through it when burned with the thin fuel bed customary in a boiler furnace, and that this excess of air reduced the efficiency by carrying a large amount of heat out of the chimney.

To avoid this effect furnaces were constructed as shown on

Deep Furnace for Boiler Burning Coke



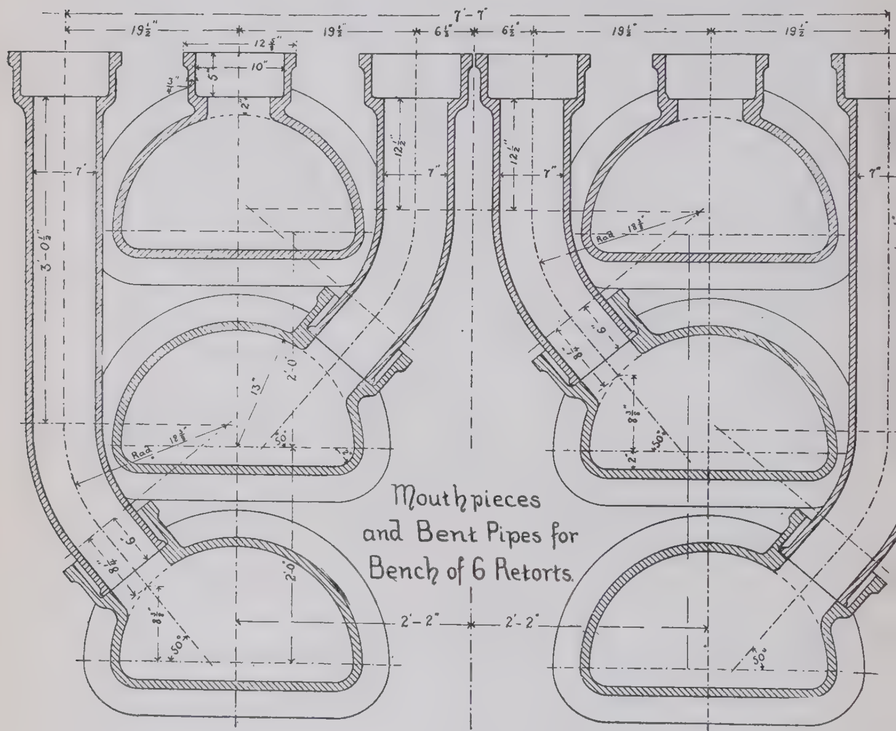
the cut. These furnaces are made much deeper than the ordinary ones, the distance from the grate bars to the bottom of the boiler being not less than four feet. It is thus practically a generator furnace. The primary air is admitted through the ash pit in the usual way, and a supply of secondary air enters through two air ports, one in each side wall of the furnace just below the boiler front. Each port opens into a flue in the side wall which runs back to the bridge wall, and into two flues in this wall. From one of these the air escapes by openings to the front and from the other by openings to the back, as shown on the cut. The secondary air required is thus delivered from both the front and the back of the bridge wall to the gas produced in the deep fuel bed. The amount of secondary air admitted must, of course, be proportioned to the amount of gas being produced in the furnace.

While with the ordinary boiler furnace coke had been found to give evaporative results from 10% to 15% lower than those obtained from steam coal in the same boilers, when the furnaces described were used the evaporative efficiency of the coke was brought up to an amount equal to that of the coal. The work of firing with this furnace is stated to be easier than with the ordinary grate and steam coal. The repairs are small and the fire has to be clinkered only once in a day of twenty-four hours. (Trustees.)

4. Give a drawing showing by a section through the centre lines of the bent pipes the layout for the bells on the mouth-pieces and for the bent pipes for a bench containing six retorts, of the cross section given on the cut accompanying the answers to Question No. 2, Second Series, set in two vertical rows of three each, the centres of the retorts in each row being 2′ 3″ from the centre line of the bench and 2′ 0″ apart vertically. The pipes are to be 7″ in diameter. The hydraulic main is 9′ 9″ long over all, and has a 3″ angle iron at each end, the space between these angles being 9′ 3¾″. The drawing must be fully dimensioned. Give also a written explanation of your reasons for adopting the design shown.

Ans. One of several possible ways of making the bells on

the mouthpieces, and the bent pipes, for the bench of six retorts described in the question is shown on the cut. The mouthpieces are designed to be the full size of the retort all through, this being very necessary for retorts that are to be drawn by machinery. The bells are made large so as to leave plenty of room for the joints around the spigot ends of the



bent pipes, it being difficult to make these joints tight when the space left for them is too small. The curved portions of the bent pipes themselves are made with as large a radius as it is possible to have on the two which pass up in the space between the top mouthpieces. This radius being sufficiently large to give a good sweep, has also been adopted for the pipes passing outside of the top mouthpieces in order

to have all the bends the same, and to save the pattern work, even though here a longer radius could have been used. The part of each bent pipe which enters the bell has been made straight to make it easier to secure a good joint. The different bent pipes have been made of such lengths as to bring all the bells into which the standpipes enter, including those on the top retorts, on the same level, since this gives to the front of the bench a much neater appearance than it has when these bells are at different heights.

If wrought iron stand-pipes are to be used, the diameter of the bells on the top mouthpieces and bent pipes can be reduced a little if desired, and for the sake of simplifying the construction and reducing the weight of the mouthpieces some engineers make them without bells, providing instead seats to which the flanged ends of the bent pipes, or of short flanged bells for the top retorts, can be bolted. (Trustees.)

5. A boiler using a fuel with a calorific value of 13,800 B. t. u. per pound is shown by a test to be evaporating 8.5 pounds of water per pound of fuel used. The water is fed to the boiler at a temperature of 115° F., and the gauge pressure is 95 pounds. What is the efficiency of the boiler? Give your calculations.

Ans. From the steam tables it is found that the total heat above 32° F. in a pound of saturated steam at a gauge pressure of 95 lbs. is 1183.9 B. t. u. Since the water is fed into the boiler at a temperature of 115° F., it already possesses a quantity of heat above 32° F. equal to $115-32 = 83$ B. t. u., so that there is imparted to it in the boiler, to convert it into steam at a gauge pressure of 95 lbs., only $1183.9-83 = 1100.9$ B. t. u. per pound. There being 8.5 lbs. of steam formed under the given conditions for each pound of coal used, the heat put into the steam, that is the useful work done, per pound of coal is $1180.9 \times 8.5 = 9357.65$ B. t. u. The combustion of the coal produces 13,800 B. t. u. per pound. Since only 9357.65 of these are used, the efficiency of the boiler is $9357.65 \div 13,000 = 67.8\%$. (Trustees.)

6. Describe some method of making iron oxide, to be used

for the removal of sulphuretted hydrogen from gas during its purification.

Ans. The iron oxide, or sponge as it is sometimes called, which is used for removing sulphuretted hydrogen from gas, is prepared by thoroughly oxidizing or rusting iron in the shape of borings and mixing it with planer chips, so as to make the material more permeable by the gas. To produce a good material, the iron must be present in sufficient quantity, must be thoroughly oxidized into the hydrated sesqui-oxide, and must be uniformly distributed throughout the planer chips.

The iron should be in the shape of cast iron borings free from oil, the finer the better, and should be used in the proportion of from 20 lbs to 25 lbs. to each bushel of planer chips. The chips should be clean and free from dust. To prepare the material, the desired number of bushels of planer chips are measured out and spread to a depth of about 18″ on a floor preferably paved with brick or cement, and are then sprinkled with water, turned, again sprinkled and turned, and so on until the whole mass is uniformly wet, but not soggy. This wetting of the chips is for the purpose of causing the particles of iron to adhere to them. An amount of iron borings equal to 5 lbs. per bushel of chips used is then weighed out, spread evenly over the top of the wet chips and mixed with them by turning the mass and wetting it while it is being turned. This operation is repeated until the whole amount of iron to be used has been added and is mixed evenly throughout the mass, which on the last turning is brought up to a depth of 24″.

The iron by this time should have begun to oxidize rapidly, and the heat produced by this oxidation will cause the mass to grow quite hot. To prevent the temperature from becoming excessive, as well as to expose fresh surfaces of the iron to the oxidizing influence of the water and the air, the mass must be turned and wet at comparatively short intervals. It may at first have to be turned every ten or twelve hours, but as the oxidation of the iron becomes more complete, the heating will not be as rapid, and the intervals can be made longer. In any case these intervals must be sufficiently short to keep

the mass damp and prevent any dehydration of the oxide by overheating and drying. The wetting and turning must be continued until all the iron is thoroughly oxidized, the attainment of this condition being shown by the cooling down of the mass, by the changing of the color to a reddish brown, and by the absence of any particles of unoxidized iron as determined by a close inspection of the mass. During the several turnings care must be taken to break up all the lumps found, since the iron in the interior of such lumps cannot be acted upon by the air and the water. When the oxidation is complete, the chips should all be covered with oxide and should not adhere to each other.

Brine and ammoniacal liquor are sometimes used for wetting the chips and the iron instead of water, the oxidation of the iron being hastened by their use. Sawdust is also sometimes used in place of planer chips, the argument in its favor being that there is less loss of oxide by its blowing away as dust during the handling of the material when in use than occurs when the chips are employed. The oxide made with chips does not, however, pack as tightly in the purifiers as does that made with sawdust, and therefore does not throw as much pressure, and the majority of engineers prefer oxide made with them to that made with sawdust. (Trustees.)

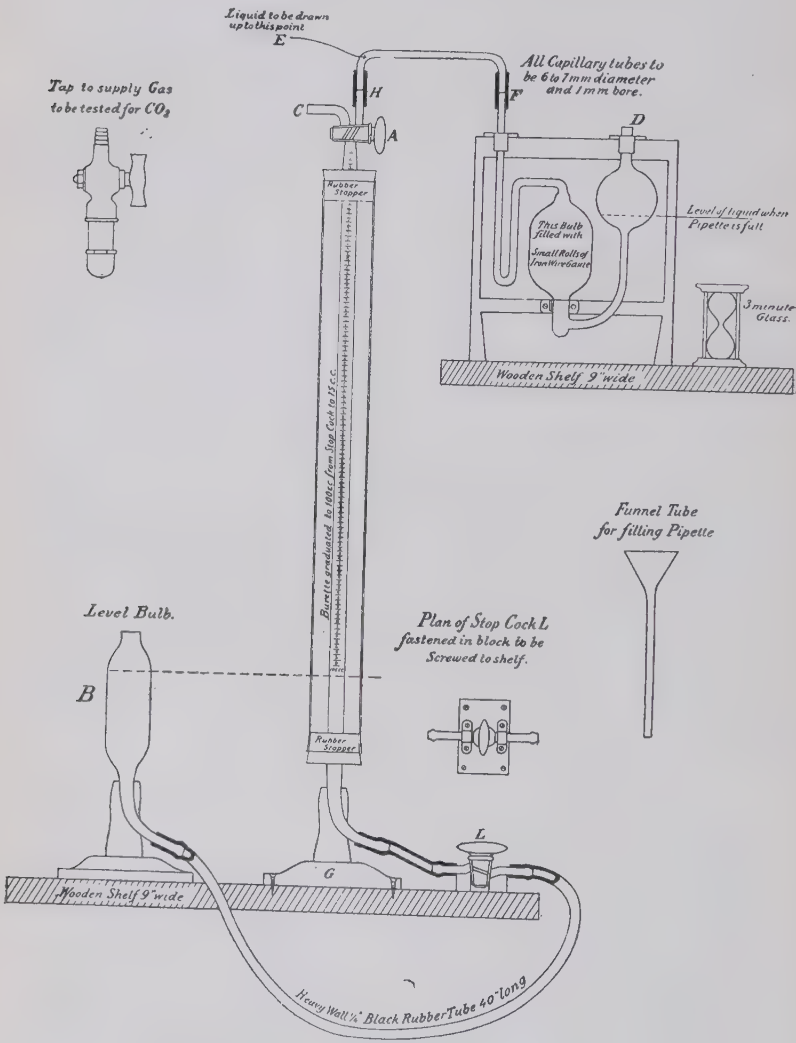
7. How would you make quantitative tests for carbonic acid and sulphuretted hydrogen in gas? How much by volume of each would you expect to find in coal gas and in carburetted water gas at the inlets to the purifiers?

Ans. "A rapid estimation of the carbonic acid in gas can be made as follows:

"The apparatus employed is shown in cut. It consists of a water jacketed graduated burette provided at its lower end with a leveling bulb and communicating at its upper end with the gas supply and the absorption bulb by means of a three-way stop-cock.

"It has a capacity of about 105 c. c. and is graduated in $\frac{1}{5}$ths c. c. from the stop-cock down to the 100 c. c. mark. The burette is mounted on a solid iron base, which is screwed

Apparatus
For rapid determination of Carbonic Acid in Gas.



down to a shelf provided for the purpose close to the gas supply.

"The CO_2 is absorbed by a solution of caustic potash in a pipette filled with rolls of iron wire gauze, which presents a large surface to the gas. The iron stand holding the pipette is placed on a shelf at a proper height and is connected to the burette by means of a capillary tube with rubber connections. Before making a test, the gas must be freed from sulphuretted hydrogen by passing through an oxide purifier.

"To set up apparatus: Set lower shelf about 36 inches from floor. Screw base of burette, G, firmly to shelf, placing it about half way between wall and edge of shelf. Set upper shelf at such height that the top of capillary, F, on pipette will be level with top of capillary, H, on burette. Fill pipette with potash solution as directed below, and connect parts of apparatus with rubber tubing as shown in drawing. Screw frame of pipette to the upper shelf.

"Loosen upper rubber stopper of water jacket and fill with clear water. Use distilled water if possible, as it will remain clear and free from annoying air bubbles.

"Saturate some clear water, preferably distilled, by allowing gas to bubble through, and with it fill level bulb, B, letting water run into burette as well.

"To prepare solution: Dissolve ¼ lb. of caustic potash in a half pint of water, distilled if possible.

"To fill pipette: With capillary of pipette disconnected from connection at F, pour the solution through funnel tube into pipette at D, until the round bulb is about one-quarter full. Then connect pipette and draw the solution up into capillary as directed below. When the cylindrical bulb is completely filled, the round bulb should remain nearly empty.

"Refill the pipette with fresh solution about once in six months, and carefully note the date of filling on a tag attached to pipette.

"To perform analysis: Open lower stop-cock, L, and turn three-way stop-cock, A, so that burette is open to pipette, then by lowering level bulb, B, draw the potash solution up capillary tube to the point E, just before capillary turns down, and close stop-cock, A. Leaving lower stop-cock open, turn

stop-cock, A, till capillary, C, is open to burette, and then by raising level bulb, B, fill burette completely full of water. Close stop-cock, L. Now attach rubber tube to gas supply and allow gas to flow through tube for a moment to displace air; then with gas still flowing attach free end of tube to capillary, C. Open lower stop-cock, L, and draw in gas to the 100 c. c. mark. Close stop-cock, L, and then close stop-cock, A, and detach rubber tube. After three minutes bring the level of the liquid in burette exactly to 100 c. c. mark by raising or lowering level bulb, and close lower stop-cock, L. Open stop-cock, A, to capillary, C, for a moment in order to allow surplus gas to escape. There will now be exactly 100 c. c. of gas in burette, measured under atmospheric pressure. Now open stop-cock, A, to pipette and force gas over into pipette by raising level bulb; draw gas back into burette immediately, letting the potash solution follow up capillary to point E as before, and close stop-cock A. After three minutes, by raising or lowering level bulb, B, bring the water in burette and level bulb to the same level and close stop-cock, L. Note the point at which the water now stands in burette, and the difference between this reading and the original amount taken will be the CO_2 absorbed."

NOTE.—"See that the stop-cocks are kept well greased. If a stop-cock is found to be stuck, do not apply force to turn it. It may be readily loosened by warming the glass with a cloth dipped in hot water. When apparatus is not in use, the open ends of level bulb and pipette should be closed with corks." (*Adopted from Hempel's Gas Analysis.*)

"Sulphuretted hydrogen in crude gas can be determined quantitatively by a modification of the Harcourt color test. The test is based on the fact that when gas containing sulphuretted hydrogen is bubbled through a solution of a lead salt, the intensity of color imparted to the lead solution by the passage through it of a given quantity as compared with a standard tint corresponding to a definite quantity of lead sulphide, at once enables us to determine the amount of H_2S in the gas under examination.

"The manner of conducting a test is as follows:

"Lay a piece of white paper on the table, and fix a piece of

cardboard upright in the brass clip provided for that purpose—the cardboard serves as a background against which to observe the color of the contents of the test glasses, and should receive a side light and be as clear as possible from shadows. Place the 'standard' glass, 'day light' or 'gas light,' according to circumstances, in its receptacle and dilute some of the concentrated lead syrup with twenty times its volume of distilled water, and fill one of the test glasses provided, up to the mark scratched on same, with a portion of the liquid thus prepared.

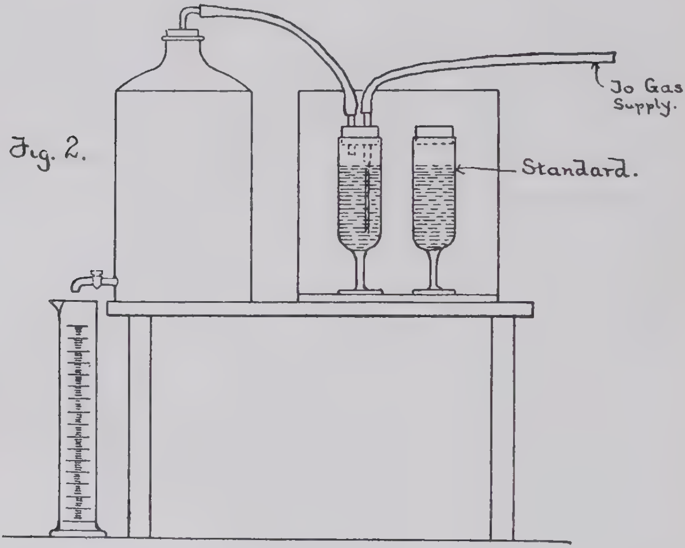
"Insert an India-rubber plug with capillary and elbow tubes, and connect up, as shown on cut, with the gas supply and aspirator, placing the standard glass and the test glass side by side on the white paper. The capillary tube should descend very nearly to the bottom of the glass, but must not press on the bottom or it will probably be broken. At starting, the aspirator should be full of water and the measuring cylinder empty. Turn the tap of the aspirator gradually, a stream of bubbles will rise through the lead solution. Turn off the tap for a minute, and observe the liquid at the bottom of the capillary tube. If it gradually rises, the India-rubber connections are not tight and must be made so before proceeding any further. It is necessary to avoid pressing the plugs into the test glass or the aspirator while they are connected, which would drive up the lead solution into the inlet tube.

"When the connections are air-tight, allow the water to run into the measuring cylinder in a slender stream until the lead solution has become as dark as the standard. As the ascending bubbles interfere with the observation of the tint, it is best to turn off the tap when the color seems almost deep enough; compare the two, turn on the tap if necessary for a few minutes, then compare again, and so on until the color of the two liquids is the same. The volume of water which the measuring cylinder now contains is equal to the volume of gas which has passed through the lead solution. This volume of gas contained a quantity of sulphur as sulphuretted hydrogen, which, as lead sulphide, has colored the liquid in the test glass to the same depth as the standard tint. The standard has been made such, that to impart this tint to the solution of liquid contained in the glass, 0.0187 grains of lead

sulphide must be present, containing 0.0025 grains of sulphur.

"For most tests for sulphuretted hydrogen on crude gas, a measuring cylinder, containing $\frac{1}{200}$ of a cubic foot and divided into 100 parts, is used. Each division represents $\frac{1}{20,000}$ of a cubic foot, and if the water from the aspirator in a test occupies x divisions, then $\frac{x}{20,000}$ cubic feet of gas contain sulphuretted hydrogen equivalent to 0.0025 grains of sulphur.

Fig. 2.



Test for Sulphuretted Hydrogen

Therefore, 100 cubic feet of gas contain $\frac{5,000}{x}$ grains of sulphur as sulphuretted hydrogen, since $\frac{x}{20,000}$: .0025 = 100 : number of grains of sulphur in 100 cubic feet. For gas containing less than 50 grains of sulphur per 100 cubic feet, a larger measuring cylinder should be used. One hundred grains of sulphur represents 106¼ grains of sulphuretted hydrogen." (*Hornby Gas Engineer's Laboratory Handbook and Butterfield Gas Manufacture.*)

Another method of determining the amount of sulphuretted

hydrogen in illuminating gas with a portable apparatus for the purpose is that devised by Mr. C. C. Tutwiler. "To describe the apparatus briefly, it consists of an absorption burette, provided with 3-way glass stop-cocks above and below, the upper one having a connection for the intake of gas and also connecting with a measuring tube surmounting it. This measuring tube is divided into C.C., which are again divided into tenths, holding altogether 10 C.C. of the iodine solution. This solution is carefully prepared, so that each C.C. contains 0.0017076 grammes of iodine, which is calculated to absorb 100 grains of H_2S per 100 cubic feet of gas. In the lower part of the burette is admitted about 5 C.C. of a starch solution made by dissolving one gramme of pure starch in 150 C.C. of water. After the burette has been filled in the usual manner with 100 C.C. of the gas to be tested, the iodine is trickled in drop by drop, with frequent shaking of the burette. As long as H_2S is present, the iodine is neutralized by it and does not affect the starch water, but as soon as all the H_2S present in the gas has been neutralized, any excess of the iodine will turn the formerly clear white starch water blue, and the operation is then stopped. Readings of the scale on the measuring tube taken before and after the operation give the amount of iodine used to take out the H_2S, and a simple calculation will then give the number of grains of this impurity. If, for instance, we consumed 4.6 C.C. of the solution, we find that we had 4.6×100 or 460 grains of H_2S in 100 cubic feet. The possible error with careful manipulation is said not to exceed 10 grains."

The percentages of carbonic acid and sulphuretted hydrogen found in coal gas at the inlet to the purifiers will vary with the efficiency of the washing and scrubbing apparatus through which the gas passes before reaching this point, since the ammonia in the gas can, by proper treatment, be made to combine with a large proportion of these impurities and remove them from the gas before it enters the purifiers. The percentage of sulphuretted hydrogen will also vary with the percentage of sulphur in the coal from which the gas is made.

Very little has been published in relation to the quantities of these impurities in coal gas made from American coals. In

a paper read before the New England Association of Gas Engineers, Mr. Carroll Miller gave some figures which showed that the average amount of sulphuretted hydrogen at the inlet to the purifiers, in coal gas made from Pennsylvania gas coal, at the works under his charge, was about 446 grains per 100 cubic feet. This gas had been passed through rotary scrubbers of the Standard type before going to the purifiers. Dr. E. G. Love has kindly given some figures he obtained in analyzing gas made from a mixture of Pittsburg, Fairmount and cannel coal. The gas at the inlet of the washer scrubber contained 918 grains of H_2S per 100 cubic feet, equal to 1.45%, and 785 grains of CO_2 per 100 cubic feet, equal to 0.97%. At the outlet of the washer scrubber, that is, at the inlet to the purifiers, the figures were 254 grains, equal to 0.40%, H_2S, and 693 grains, equal to 0.85%, CO_2. The gas from coals containing more sulphur, such as most of the West Virginia coals, would, of course, contain more sulphuretted hydrogen. Butterfield gives the amount in well-washed gas made from Durham coal as 500 to 800 grains per 100 cubic feet, equal to from 0.79% to 1.26%. This coal contains from 2½ to 3 times as much sulphur as Pittsburg coal. According to the same authority the carbonic acid will vary from 700 to 1100 grains per 100 cubic feet, equal to from 0.86% to 1.35%.

In the paper mentioned above Mr. Miller gives the average amount of sulphuretted hydrogen in carburetted water gas made from gas coke and Pennsylvania oil as about 190 grains per 100 cubic feet of gas. As in coal gas the percentage of this impurity will depend on the amount of the sulphur in coal or coke used, and also upon the amount in the oil. Butterfield gives the figures for English practice as 0.15% to 0.25%. The percentage of carbonic acid will depend largely on the manner in which the apparatus is run and upon the fuel used, gas made from anthracite containing less than gas made from coke, other things being equal. The amount, assuming careful operation, may be taken as varying from 2.5% to 4.0%. (Trustees.)

8. If you had a set of purifiers consisting of four 12′ × 14′ × 4′ boxes in which you wished to use oxide of iron in one

layer of 3′ 0″ deep in each box, how many bushels of oxide would you buy or make up? The amount given should include not only the oxide actually in the boxes at any one time, but also that which it would be necessary to have on the floor at the same time, to make it certain that each lot of oxide would be afforded the opportunity for complete revivification. Give the reasons for your answer.

Ans. The volume of oxide of iron required to fill a purifying box 12′ wide and 14′ long to a depth of 3′ 0″ will be $12 \times 14 \times 3 = 504$ cu. ft. Purifying material being measured by the struck bushel, which contains 2,150 cubic inches, or 1.24 cubic feet, 504 cu. ft. will be $\frac{504}{1.24} = 406$ bushels, so that each batch of oxide will have to contain 406 bushels.

The number of batches that should be kept in use for a set of four boxes will depend somewhat upon the area of the space available for revivifying purposes. It is very important that the oxide should be fully revivified before it is put back into the purifying box, since if not so revivified it cannot do good work, and any attempt to get along with an insufficient number of batches leads to continuously deteriorating results. Therefore, when it is possible to secure the necessary area, it is best to keep in use eight batches, each box having its own two batches, which are used only in it. This allows each batch to remain on the revivifying floor at least four days, even when the conditions are so bad that it is necessary to change a box every day. If working under better conditions there is still more time for revivification and the oxide is in just that much better shape, since the longer it remains exposed to the air under favorable conditions the more certain it is to be thoroughly revivified.

If it is impossible to secure sufficient area to permit of handling the eight batches, seven or even six can be made to do, although the working will not be as satisfactory as with the larger number. But even under this condition a volume of oxide equivalent to either one or two batches should be kept on hand, in addition to that in actual use, so as to be able to allow a batch that does not revivify in time to be used

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in its turn, to be set aside and replaced from the stock. It is therefore necessary in the case given to buy, or make up, $8 \times 406 = 3,248$, or say 3,250 bushels of oxide. (Trustees.)

9. How does the calorific value of gas affect the consumption per horse power in a gas engine, and what do you consider a fair average rate of consumption per brake horse power for a 10 horse engine using a gas having a net calorific value 600 B. t. u. per cubic foot?

Ans. A gas engine is a heat engine, that is, an engine in which energy in the form of heat is converted into mechanical energy, and, since a definite amount of heat is required to produce any given amount of mechanical energy, it follows that the greater the calorific value of the gas used in a gas engine the smaller the amount required per hour per horse power developed. If the gas engine were capable of using, with the same efficiency, gases of any calorific value, the respective amounts of the different gases required per hour per horse power would vary inversely as their calorific values. It is found, however, that for various reasons gas engines work a little more efficiently when using gas of comparatively low calorific value, 150 to 300 B. t. u. per cubic foot, than they do when using gas of higher calorific value, 500 to 1,000 B. t. u. per cubic foot, so that they require somewhat less of the low value in comparison with the higher value gas, than is called for by the relation between the calorific values.

In any case the consumption of gas per horse power will vary with the condition in which the engine is kept and upon the proportion between the load it is carrying and that which it is capable of carrying, since when working at or near its full load the engine has a greater mechanical efficiency than when running under a small load. Under favorable conditions a 10-horse power gas engine can be run on a consumption of 21.5 cubic feet per brake horse power per hour when using gas of a calorific value of 600 B. t. u., but the average consumption under actual working conditions will be about 25 cubic feet per brake horse power per hour. (Trustees.)

10. If you were sent to a house to investigate a complaint

of "poor gas," how would you proceed to determine the cause of the trouble?

Ans. It is assumed in this answer that it is known that the main in the street and the service into the house are both of sufficient size to insure a proper pressure at the head of the service at all times if there is no stoppage in the service, that the house-piping is of the proper size, and that the burners are in good order.

First determine, either by inquiry from the consumer or by investigation, the nature and location of the trouble. If it is general, that is, occurs all over the house, the cause must be sought in the service, meter, or the riser between the meter and the first branch pipe. If it is confined to one floor or one room, it is only necessary to examine the portion of the system which supplies that floor or room.

Poorness of light due to a uniform low pressure without fluctuation indicates the existence at some point of an obstruction formed by a solid matter. A quick, sharp jumping of the flame shows an accumulation of liquid at some point, and a slow rise and fall of the size of the flame which takes place at comparatively long and irregular intervals is a sign that the meter is overloaded or else sticks at some point. If intelligent information as to the above points can be obtained from any of the inmates of the house, the procedure can be governed accordingly. If this information cannot be had, it will be necessary to secure it by lighting burners in various parts of the house and in sufficient number to test the steadiness of the delivery of the meter, and then determine from observation of the flames the probable cause of the trouble.

If the trouble is located on a particular floor or in a particular room, examine and clean the burner keys and the bracket swings, and if this does not remedy it explain to the consumer just where you think the stoppage is located, and tell him to call in a plumber and have it removed, but do not take off the chandelier or brackets.

If the trouble is general and seems due to an obstruction of solid matter, take out the plug in the tee where the service comes through the cellar wall and determine whether the

service is clear, either by observing the amount in, and the force with, which the gas escapes through the open end of the tee, or else by blowing into the service with the lungs. If it is found not to be clear, try to clear it by the use of a wire and air-pump, or by the use of gasolene or naphtha followed by the pump. If the service is clear, examine the inlet connection of the meter, and then, if necessary, the outlet connection, being particularly careful to see that these connections have not been flattened in any place so as to shut off the flow of gas.

When an accumulation of liquid at some point is suspected, test the service as above. The presence of water can be readily detected by the intermittent flow of gas, as well as by the gurgling noise made by the gas as it bubbles through the water. If water is found, blow it out with the pump. If the service is clear, take out the meter drip-plugs to see if any water has condensed and lodged in the meter drips.

Test the meter also by leaving it connected on the inlet and taking off the outlet connection so as to allow the gas a free passage through it, and note the rate and the steadiness with which it flows. This meter test should also be made where an obstruction of solid matter is suspected but cannot be located in the service or the meter connections.

A general trouble that cannot be found in either the service, meter, or meter connections must be in the house piping, and if the stoppage cannot be removed by running a wire up the main riser or by blowing out the exposed pipes in the cellar, locate it as closely as possible, tell the consumer where you believe it to be, and advise him to call in a plumber to clean it out. If water is found in the service, notice should be given the main laying department so that the service can be taken up and relaid to a proper grade. (Trustees.)

11. An instantaneous water heater burning gas at the rate of 75 cubic feet per hour will heat water from a temperature of 50° F. to one of 117° F. at the rate of 68 gallons per hour. The gas has a net calorific value of 620 B. t. u. per cubic foot. What is the efficiency of the heater?

Ans. Under the conditions stated in the question of heat

developed in the heater per hour by the gas used is 75 (number of cubic feet of gas consumed per hour) $\times$ 620 (calorific value of a cubic foot)=46,500 B. t. u. The useful work done is measured by the amount of heat put into the water passing through the heater. The temperature of the water is raised $117-50=67°$F. and the weight heated to this extent is 68 (number of gallons heated per hour) $\times 8.33$ (weight of a gallon of water in pounds)=566.44 lbs. Therefore, the gas consumed does an amount of useful work equal to $566.44 \times 67=$ 37,951 B. t. u. and the efficiency of the heater is $\frac{37951}{46500}=81.6\%$ (Trustees.)

12. Describe the proper method of laying brick in holder tank work.

Ans. Baker's Treatise on Masonry Construction gives the following instructions: "Brick should not be merely laid, but every one should be rubbed and pressed down in such a manner as to force the mortar into the pores of the bricks and produce the maximum adhesion; with a quick-setting cement this is still more important than with lime mortar. For the best work it is specified that the brick shall be laid with a 'shove joint;' that is, that the brick shall first be laid so as to project over the one below, and be pressed into the mortar and then be shoved into its final position.

"Since bricks have great avidity for water, it is best to dampen them before laying. If the mortar is stiff and the brick dry, the latter absorb the water so rapidly that the mortar does not set properly and will crumble in the fingers when dry. Neglect in this particular is the cause of most of the failures of brick work. * * * * Wetting the brick before laying will also remove the dust from the surface, which otherwise would prevent perfect adhesion."

There is among constructors a difference of opinion as to how the bricks should be put into the wall. The following is from a man who has had considerable experience in tank work, and whose tanks have been tight:

"The bricklayer should put only enough mortar on the wall to embed one brick, place the brick in the mortar, then give it a sliding motion in two directions to fill the joints on one end

and on one side, and to expel the air from under the brick. The mortar should then be cut off the top and returned to the board.

"It is impossible to accurately describe how to push brick; the only way is to get a brick mason that can and will do this kind of work and have him instruct each mason that is taken on the job how the work is to be done."

An advocate of grouting, who has been perfectly successful in tank work, writes as follows: "The thickness of joint being decided upon, the outside and inside circle should be laid up five courses, making a trough for filling in. Spread thick mortar in the bottom of this trough and lay the brick in this mortar, care being taken that the brick shall be put down in such a manner as to drive all the air out as they fall into place. This makes a full joint under the brick. Then grout with mortar to be thrown over the tops of these bricks from a bucket in the same manner as coke is quenched, the mason using his trowel to fill in any joints that are not filled by spreading the mortar in this way. On this layer of bricks spread another layer of stiff mortar and lay another course of brick, grouting in these as in the former case. Care should be taken to arrange headers and stretchers, so that there will be a good bond.

"By pursuing this method, a fair mason can lay from 1,800 to 2,200 bricks per day; 2,100 to 2,200 bricks were laid per day, per mason, under my supervision. The brick for the inside and outside circle should be wetted with a hose. The brick for filling in should be thoroughly wetted, and I would advise having a number of tubs placed at intervals on the scaffold, and the brick thoroughly soaked with water in these tubs before being put in the wall; in fact, the brick should be taken from the tubs and placed in the wall without giving them any time to dry."

There can be no doubt that entirely satisfactory tanks have been built by each method. It is probably equally true that a mason can lay from 200 to 400 more bricks a day by adopting the second or grouting method. It is also probably true that more close supervision is required to obtain good work with the grouting system. (Trustees.)

Second Series of Questions—Section of 1909—Practical Class—American Gas Light Association.

1. What precautions should be taken to avoid spontaneous combustion in bituminous coal stored in a coal shed?

2. The furnaces employed for heating coal gas retorts may be divided into two general classes. What are these classes, what is the distinctive difference between them, and what advantages has either one over the other?

3. In the manufacture of carburetted water gas it is customary to have the water gas pick up the oil, in a state of vapor, at the entrance to the fixing vessels, and carry this vapor and the resulting gas through these vessels, the oil gas being thus made in the presence of the water gas. What advantages has this method over that of making the oil gas entirely separate from the water gas?

4. Give a description, illustrated with sketches, if necessary, of one or more forms of apparatus for removing heavy tar from gas, and state the position in the sequence of apparatus that should be occupied by the tar extractors, with your reason for such location.

5. Define the term Specific Gravity of a Gas. Give the limits between which you would expect the Specific Gravity of Coal Gas to vary. Same for Carburetted Water Gas. How do you account for the difference in Specific Gravity between the gases?

6. Give the weight of a cubic foot of each of the following gases when dry and at a temperature of 60° F. and a pressure of 30″ of mercury:

   Air
   Carbon Dioxide, CO_2
   Carbon Monoxide, CO
   Marsh Gas, CH_4
   Hydrogen, H
   Oxygen, O
   Nitrogen, N
   Ethane, C_2H_6
   Ethylene or Olefiant Gas, C_2H_4

7. Describe the ordinary qualitative tests for the presence in gas of Tar, Ammonia (NH_3), Carbon Dioxide (CO_2), and Sulphuretted Hydrogen (H_2S), and state at what points in the apparatus the test for each should be made in order to determine that the gas is being properly purified. Give your reason in each case.

8. What is the meaning of "candle power" in the statement "this is a 20-candle power gas?"

9. Having provided dip-pots at the proper points in the Street Main system, what further precaution is necessary to prevent trouble from accumulation of condensation?

10. What principles govern the efficient combustion of gas for the production of light, and what details of construction have been adopted in the most improved forms of flat flame burners of the batswing or slit type to carry out these principles?

11. Why are Bunsen or Atmospheric burners used in gas cooking stoves and incandescent gas lights? Why are they not used in the ordinary cylindrical gas heating stoves and gas radiators?

12. What considerations would determine your choice between lime mortar and cement mortar for use in any given job of brick or stone masonry?

(Answers to these questions are due June 1st.)

Answers to the Second Series of Questions—Section of 1909—Practical Class—American Gas Light Association.

1. What precautions should be taken to avoid spontaneous combustion in bituminous coal stored in a coal shed?

Answer. To guard against spontaneous combustion in bituminous coal stored in a coal shed, care should be taken

that no excessive breakage occurs during the handling of the coal into the shed; that it is dry and large when received and is handled only in dry weather; that it is well protected from the weather when in the shed, and that it is not exposed to external heating as would be the case if it was stored in close proximity to a boiler or bench of retorts or over steam pipes. The floor of the shed should be dry, and made of incombustible materials, and all roof or track supports passing through and imbedded in the coal should be made of iron or brick. If the storage of wet or fine coal cannot be avoided, no large amount of such coal should be piled together in any one place, but it should be, as far as possible, distributed in a thin layer over the face and top of the pile and allowed to become thoroughly dry before being covered with any other coal. It is best not to attempt any ventilation of the pile, since insufficient ventilation is much more dangerous than none at all, and from the nature of the case it is practically impossible to obtain sufficient ventilation. It is also well not to store coal recently mined, at least a month being allowed to elapse after mining before the coal is stored.

The taking of these precautions will tend to prevent the occurrence of any spontaneous increase in the temperature of the coal, since this increase is probably due chiefly to the condensation and absorption by the coal of oxygen from the air, which causes heating, and thus promotes the chemical combination of the oxygen with the volatile hydrocarbons in the coal, and even with some of the carbon itself. The conditions favoring the occurrence of this action to an extent sufficient to generate enough heat to effect the ignition of the coal are "moderately high external temperature; a broken condition of the coal, affording fresh surfaces for absorbing oxygen; a supply of air sufficient for the purpose, but not in the nature of a strong current adequate to remove the heat; a considerable percentage of volatile combustible matter or an extremely divided condition." The action of moisture upon the sulphur present in the form of iron pyrites is a secondary cause of heating, principally because of its effect in breaking up the coal and presenting fresh surfaces for the absorption of oxygen.

To detect the existence of any heating before it has reached a dangerous point, 1" pipes should be either set up on the floor of the shed so as to be imbedded in the coal as the shed is filled, or else should be driven through the coal after the shed is filled. These pipes should be closed at the bottom, should reach from the floor of the shed to a point just above the top of the coal and should be spaced not more than ten feet apart, from centre to centre, throughout the whole space filled with coal. In each pipe should be placed a wire stretched by the weight of a small iron rod suspended from it and just long enough to allow the point of the rod to touch the bottom of the pipe. By keeping one hand closed around the wire and slowly drawing it up until the rod is reached, the existence of any abnormal temperature can be detected and the place where it occurs located. The exact temperature existing at any hot point can be determined by lowering thermometers down the pipes in which the wires are found to be heated. Under normal conditions, where there is no reason to anticipate trouble, the inspection of the condition of the wires need not be made oftener than once a week, but when any heating has been found, no matter how slight it is, or there is reason to believe that it may occur, observations should be made at least once a day. If the temperature becomes high at any point and continues to rise, steps should be taken at once to prevent any ignition of the coal. The safest method is to work into the pile at the hot point, and expose the coal that is heating to the air by spreading it out in a thin layer. As long as the coal has not begun to burn, this will stop the heating. If the coal has fired, the fire must be uncovered and then extinguished. It is of very little use to try to put out the fire without digging down to the coal that is burning. (Trustees.)

2. The furnaces employed for heating coal gas retorts may be divided into two general classes. What are these classes, what is the distinctive difference between them, and what advantages has either one over the other?

Ans. The two general classes into which the furnaces employed for heating coal gas retorts may be divided are direct fire or plain furnaces and generator furnaces.

The distinctive difference between the two classes lies in the manner in which the combustion of the carbon in the fuel is effected. In the plain, direct fire furnace the carbon is burnt to carbon dioxide (CO_2) in the furnace, the combustion being completed in the fuel bed, while in the generator furnace the combustion is performed in two stages, the carbon being burnt to carbon monoxide (CO) in the furnace, this carbon monoxide (CO) being then burnt to carbon dioxide (CO_2) in a combustion chamber in the setting, into which a supply of air is introduced for this purpose.

The only advantage possessed by the plain as compared with the generator furnace is that of lower first cost, it being cheaper to build a setting with a plain furnace than it is to build one with a generator furnace.

On the other hand, to insure even approximately complete combustion of the fuel in the plain furnace the use of a large excess of air is necessary, the total amount required being two or three times as much as is theoretically necessary, while in the generator furnace where the air supply can be, and is, closely regulated, perfectly complete combustion can be obtained by the use of an amount of air not more than 10% to 15% in excess of the theoretical requirements. Since all the air passing through the furnace and setting must be heated to the temperature of the setting, the great reduction in the amount of air so passing secured by the use of a generator furnace permits the attainment of a higher temperature in the setting, when such a furnace is employed, and at the same time diminishes the amount of heat carried away from the setting by the waste gases, and therefore reduces the amount of fuel required to carbonize the coal.

The temperature in the furnace itself being higher in the direct fire furnace than it is in the generator furnace, the clinker formed is harder and the cleaning of the fire is a more difficult operation in the first class of furnaces, while the construction of these furnaces is such that a strong current of cold air flows through the setting during the whole time occupied in this cleaning. This cools the retorts and causes them to crack. The fire in the generator furnace can be cleaned without causing any such flow of cold air through the

setting, and this style of furnace therefore possesses the further advantage of prolonging the life of the setting by maintaining it at a uniform temperature at all times. (Trustees.)

3. In the manufacture of carburetted water gas it is customary to have the water gas pick up the oil, in a state of vapor, at the entrance to the fixing vessels and carry this vapor and the resulting gas through these vessels, the oil gas being thus made in the presence of the water gas. What advantages has this method over that of making the oil gas entirely separate from the water gas?

Ans. The principal advantage that is thought to be obtained by carrying on the manufacture of carburetted water gas so that the oil gas portion is made in the presence of the water gas instead of being made entirely separate from the water gas, is that the presence of the water gas shields the oil gas from the heat and renders it less subject to over-decomposition in case the temperature of the heated surfaces is too high or the exposure to the heat too prolonged. The effect upon the oil vapors and gas of exposure to heat of too great intensity or for too long a time is to produce hydrocarbon gases of low illuminating values, or hydrocarbon vapors, which, although they are of high illuminating value, can be carried by the gas only to a limited extent. By separating and surrounding the molecules of the oil vapors and gas, the water gas reduces the extent to which they are exposed to the heat and so reduces the liability to over-decomposition.

On the other hand, it is possible that an excess of water gas will exert so great an effect as to interfere with the complete gasification of the oil, and in cases where the amount of exposure is small, or the intensity of the heat low, the presence of water gas during the decomposition of the oil may be detrimental. This, however, will not occur in an apparatus that is properly designed and handled.

Another advantage of making the oil gas in the presence of the water gas is that the latter will pick up and carry oil vapors that escape gasification, and, if the water gas was not present, would be condensed and left behind when the oil gas was cooled. These vapors are of value as illuminants, and so

the candle power of the carburetted water gas made in this way will be higher for an equal amount of oil used than will be that of carburetted water gas made by making the water gas and oil gas separately and mixing them cold. This advantage can, however, be obtained to a great extent even when the two gases are made separately by mixing them hot.

This method of making carburetted water gas also makes it possible to conveniently arrange the apparatus so that the heat required for the gasification of the oil can be furnished very economically by the combustion, and partly by the sensible heat, of the producer gas formed in the generator while the fuel is being heated up to the temperature required for the manufacture of water gas. (Trustees.)

4. Give a description, illustrated with sketches if necessary, of one or more forms of apparatus for removing heavy tar from gas, and state the position in the sequence of apparatus that should be occupied by the tar extractors, with your reason for such location.

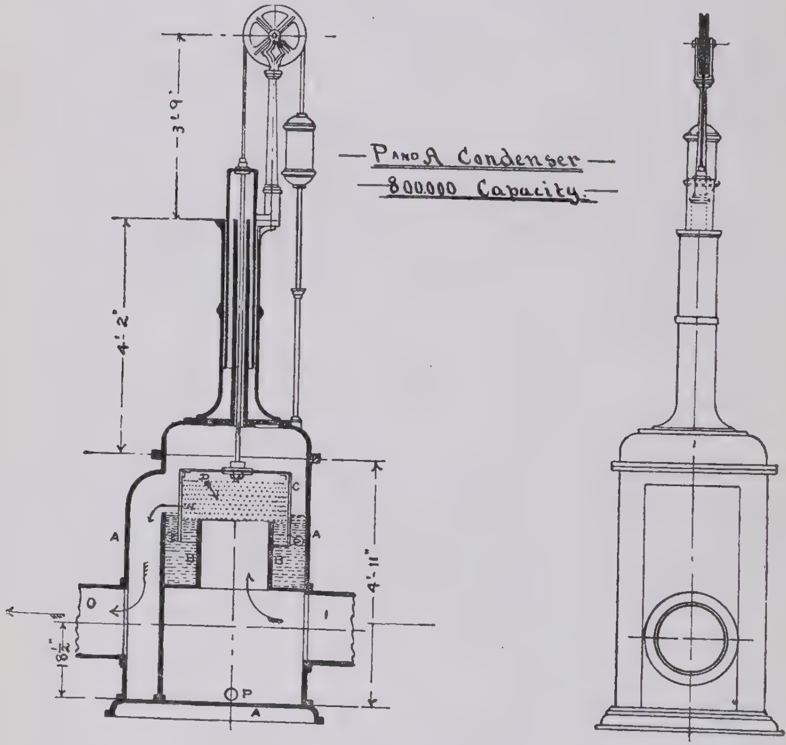
Ans. One method of removing tar from hot gas is founded upon the principal that deposition of the vesicles of tar held in suspension in the gas may be effected by bringing these vesicles into contact with solid surfaces, or with each other. The Pelouze and Audouin, founded upon this principle and designed for use with hot gas, is a very efficient and compact form of apparatus for the removal of heavy tar from gas.

The action of the apparatus is as follows: The gas to be purified is made to flow through a series of holes of small diameter, so forming jets, which strike against a surface situated directly opposite. In the passage of the gas through the holes, the liquid molecules are brought into close contact with each other, and the operation is completed by the contact with the solid surface upon which the tarry matter is deposited.

The apparatus is represented in the cut, part shown as broken away in order to explain more clearly its action. AAA is the outer case, to which are attached the inlet and outlet pipes, I and O. Concentric with the case is fixed an annular tank BB, in the middle of which is left a free passage for the gas. This annular tank is charged by preference with dead oil

obtained from tar, and in it is suspended the bell or holder C, counterbalanced as represented.

The sides of the bell C for a portion of its height is formed of three or more concentric cylinders which are separated by a space of about three-eighths of an inch between them. Each cylinder is pierced, as represented at D, with a number of rows



of holes each about one-twentieth of an inch in diameter, which are so placed that the gas in passing through the orifices of one of the cylinders impinges against the plate of the next; by this means all the tarry vesicles are broken up in a manner so complete, that when the apparatus is dispensed with, a piece of writing paper being exposed to the influence of the gas issuing from a small jet is, in the course of two or three

seconds, rendered almost black by the deposit of the tar; whereas, when the condenser is in operation under like conditions, the paper is not soiled in the slightest degree. The tar is deposited on the side of the bell, whence it passes off by a suitable opening to the pipe P.

The bell, being balanced and free to move as shown, rises and falls automatically as the difference between the pressure inside and that outside of it increases or decreases, and so by the exposing, as the conditions demand, of a greater or smaller number of holes through which the gas can pass the pressure thrown by the apparatus is kept constant in spite of variations in the amount of gas made. A pressure gauge should be provided to show when this governing action is being interfered with by the clogging of the holes in the bell. When this occurs the holes should be cleaned, and the apparatus is so designed as to permit such cleaning to be done.

A form of apparatus known either as a hot scrubber or a dry scrubber is also used for this purpose. It consists usually of a rectangular shell, enclosing a space which is divided into several compartments, the gas passing through these compartments in succession. In each compartment is a series of plates so arranged that the gas is frequently baffled and forced to change the direction of its travel, and is at the same time exposed to friction in passing over the surface of the plates. The shock of the impingement on the baffle plates, added to the friction between the gas and the plates, causes the deposition of the tar just as in the P. and A. condenser. As, however, the gas is not divided into small streams, as in the latter form of apparatus, the dry scrubber must be made much larger if it is to handle the same quantity of gas per day.

The heavy tar extractor should be so located in the sequence of apparatus as to receive and treat the gas before it has been cooled down below 100° F. It may be placed after the exhauster when the gas leaves the latter at a temperature above 100° F., but should be placed before the exhauster when the gas leaves the latter at a temperature below that point.

The reason for so locating the tar extractor is that the heavy tar has, when cold, the property of absorbing from the gas

the vapors of the lighter liquids, which vapors if not absorbed in this way would remain suspended in the gas. They are very efficient in adding to the light-giving value of the gas, and if the tar is allowed to absorb them the illuminating value of the finished gas is made lower than it will be when they are kept in it. At a temperature above 100° F. the tar does not seem to have any appreciable effect upon them, so if it is removed while the temperature is above that point it is prevented from exerting any harmful influence upon the illuminating value of the gas. (Trustees.)

5. Define the term specific gravity of a gas. Give the limits between which you would expect the specific gravity of coal gas to vary. Same for carburetted water gas. How do you account for the difference in specific gravity between the two gases?

Ans. The specific gravity of a substance is the ratio between the weight of any given volume of the substance and that of an equal volume of some other substance selected as a standard. In the case of gases the standard commonly employed is atmospheric air, though in chemical work hydrogen is used as a standard. For our purposes the specific gravity of a gas may be defined as the ratio of the weight of any given volume of the gas to the weight of an equal volume of air, the air and the gas being measured and weighed at the same temperature and pressure.

The specific gravity of ordinary coal gas ranges from .350 to .500, air being 1.000, increasing with the candle power of the gas. The specific gravity of carburetted water gas as ordinarily made ranges from .550 to .700.

The greater specific gravity of carburetted water gas is due to the fact that it contains on the one hand smaller percentage of hydrogen, which is the lightest substance known, and of marsh gas, also a comparatively light gas (sp. gr. .554), and on the other hand larger percentages of the heavier substance carbon monoxide (sp. gr. .969) and of the heavy hydrocarbons (sp. gr. from .969 upwards) than does coal gas. Trustees.)

6. Give the weight of a cubic foot of each of the following

gases when dry and at a temperature of 60° F. and a pressure of 30″ of mercury:

Air	
Carbon Dioxide	CO_2
Carbon Monoxide	CO
March Gas	CH_4
Hydrogen	H
Oxygen	O
Nitrogen	N
Ethane	C_2H_6
Ethylene or Olefiant Gas	C_2H_4

Ans. The weights of a cubic foot of the gases named when dry and at a temperature of 60° F. and a pressure of 30″ of mercury are as follows:

	Grains.	Pounds
Air.	534.5010	.076357
Carbon Dioxide CO_2	814.4191	.11634
Carbon Monoxide CO.	518.2735	.074039
Marsh Gas, CH_4	296.1563	.042308
Ethylene or Olefiant Gas, C_2H_4	518.2735	.074039
Hydrogen, H	37.0195	.0052885
Oxygen, O	592.3127	.084616
Nitrogen, N	518.2735	.074039
Ethane, C_2H_6	555.2930	.0793275

(These weights are on the avoirdupois scale. (Trustees.)

7. Describe the ordinary qualitative tests for the presence in gas of tar, ammonia (NH_3), carbon dioxide (CO_2), and sulphuretted hydrogen (H_2S), and state at what points in the apparatus the test for each should be made in order to determine that the gas is being properly purified. Give your reason in each case.

Ans. The ordinary test for tar is made by allowing a jet of gas to impinge on a piece of white paper. If a dark stain appears on the paper, tar is present in the gas. A continuous test for tar can be made by passing a stream of gas through a glass tube filled loosely with cotton wool. If tar is present in

the gas, even if only to a very small extent, the cotton will be discolored.

The test for ammonia is ordinarily made by allowing a jet of gas to impinge on moistened turmeric paper, the turmeric paper turning brown if ammonia is present in the gas. Litmus paper reddened by a weak acid can be used instead of turmeric paper and will regain its original blue color if ammonia is present. The turmeric paper is more commonly used. Directions for preparing these papers can be found in Newbigging's Hand Book, 6th edition, page 292.

The test for carbon dioxide is made by allowing a small stream of gas to bubble through lime water. If carbon dioxide is present a white precipitate of carbonate of lime will be formed, and the lime water will become cloudy owing to the diffusion of this precipitate throughout the liquid.

The test for sulphuretted hydrogen is made by allowing a jet of gas to impinge on a piece of white paper wet with a solution of acetate (sugar) of lead. The formation of a dark stain indicates the presence of sulphuretted hydrogen in the gas.

Since the object of all these tests is to determine whether or not the gas is being properly purified, the test for each substance should be made at the outlet of that piece of apparatus which is employed to remove the last traces of such substance from the gas. The proper place at which to test for tar is, therefore, the outlet of either the tar extractor or the condenser, according to which piece of apparatus is being used for the purpose of removing the tar. The test for ammonia should be made at the outlet of the last scrubber or the last washer, since any ammonia that escapes absorption in these vessels is lost so far as any return from it is concerned. The test for carbon dioxide and sulphuretted hydrogen should be made at that point in the series of purifiers at which it is desired that the purification should be complete. This is usually the outlet of the second box, if three boxes are in use, and the outlet of the third box when four are being used. (Trustees.)

8. What is the meaning of "candle power" in the statement "this is a 20 candle power gas?"

Ans. The words "candle power" in the statement "this

is a 20 candle power gas" are used to denote the amount of light given by the flame produced when any gas is burned in a standard burner at the rate of five cubic feet per hour, expressed in terms of a unit, which is the amount of light given by a standard sperm candle of six to the pound burning at the rate of 120 grains per hour. The statement "this is a 20 candle power gas" is, therefore, a statement that the gas named will, when burned in the standard burner at the rate of five cubic feet per hour, produce a flame giving an amount of light twenty times as great as that given by the standard sperm candle of six to the pound burning at the rate of 120 grains per hour.

Different forms of burners are used in different localities as the standards for the purpose of determining the candle power of gas. In England when the gas to be tested is a coal gas from 14 to 16 candle power, the burner generally prescribed by law for use as the standard burner is a special form of Argand burner known as Sugg's London Argand, No. 1. For cannel gas of from 20 to 26 candle power a flat flame burner is commonly prescribed as the standard. In this country the No. 7 Bray Slit Union burner has been very generally adopted as the standard burner, especially where the gas to be tested is either a carburetted water gas or a mixture of this gas with coal gas. The London Argand is also used in many instances for coal gas. It is always necessary to note what burner has been employed as a standard in each case before any comparison can be made between the reported candle powers of the gas supplied in different localities.

As far as the candles are concerned the only qualifications generally adopted are that they shall be sperm candles of six to the pound and shall be burned at the rate of 120 grains per hour. Wide variations in the amount of light given by different candles, all of which fulfilled the above requirements, led the London Gas Referees to adopt regulations for securing uniformity in standard candles which prescribe the method and materials to be used in the manufacture of the wicks and the melting point of the spermaceti that are to be employed in making such candles. In the absence of any regulations on the subject in this country it is well to see that the

candles used fulfill as nearly as possible the requirements of the Gas Referees. These requirements are given in full in Butterfield's Chemistry of Gas Manufacture, pages 249 and 252. (Trustees.)

9. Having provided drip-pots at the proper points in the Street Main system, what further precaution is necessary to prevent trouble from accumulation of condensation.

Ans. After having provided drip-pots at the proper points in the street main system, it is further necessary that the liquids that condense in the pipes and flow into the drips shall be pumped out at regular intervals. The length of time that it is safe to allow to elapse between two consecutive pumpings of any drip must be determined by actual experience, and should always be sufficiently short to avoid the possibility of the liquids accumulating in the drip-pot between pumpings to a height that will allow them to overflow from the drip into the pipe in which it is inserted. In the case of drips in the works, or those in the vicinity of the works on the trunk mains supplying the district, the intervals between pumping will probably vary from a few hours to one week, while in the extreme outer part of the district it is very often safe to allow the drip-pots to go unpumped for a year. All drips, no matter how small the amount of liquid they collect, should be examined at least once a year. In case the rate at which the liquids accumulate in any drip-pot shows a sudden increase an investigation should be made, the cause of the increase determined and the proper steps taken to remove this cause. (Trustees.)

10. What principles govern the efficient combustion of gas for the production of light, and what details of construction have been adopted in the most improved forms of flat flame burners of the batswing or slit type to carry out these principles?

Ans. The principles governing the efficient combustion of gas for the direct production of light are very fully set forth in part IX, chapter V. (volume 3, page 115 and seq.) of

King's Treatise on Coal Gas, from which the following summary has been taken. Members of the class should, if possible, read this chapter.

Since the light given by a flame is due principally to the raising to incandescence of particles of carbon set free by reactions occurring in the flame, to obtain the maximum amount of light it is necessary that the gas should be so consumed as to secure the setting free in the flame of the greatest possible number of carbon particles, and the raising of these particles to the highest possible temperature. These two conditions can only be secured by the proper regulation of the amount of air supplied to the gas producing the flame, and of the manner in which this air is brought into contact with the gas. The formation of the carbon particles being due to the decomposition of the hydrocarbon constituents of the gas, principally by the effect of heat, anything which tends to cause the combustion of these hydrocarbons before they are sufficiently heated to be decomposed reduces the amount of light given by the flame by reducing the number of carbon particles present in it. And since the amount of light produced by any given number of carbon particles increases with the temperature to which they are raised, anything that tends to lower the temperature of the flame also reduces the amount of light given by it.

Any admixture or intermingling of air and gas previous to the ignition of the gas reduces the illuminating power, both by partially consuming the hydrocarbons before they are sufficiently heated to be decomposed, and so reducing the number of carbon particles in the flame, and also by cooling the flame. Any overdraft by which an excess of air is brought into contact with the flame so as to be heated by it reduces the illuminating power by cooling the flame. To secure the maximum amount of light from the gas it is, therefore, necessary that the air should be brought into contact with the gas in just the proper amount required for its complete combustion, and in such a way that the contact takes place only on the surface of the flame. With flat flames the great cause of intermingling of air and gas and of excess rush of air against the surface of the flame is a high velocity of exit of the gas from the burner

tip into the atmosphere. This velocity of exit increases rapidly with the pressure at which the gas is supplied to the burner tip. It is, therefore, essential that the pressure at the tip be low. With an Argand burner this pressure can be reduced to practically nothing, but with flat flame burners a certain amount of pressure is necessary to develop the flame to its proper shape, this being especially the case with union jet (fishtail) burners.

Any swirling motion in the gas also tends to produce an intermingling of gas and air as well as a disagreeable noise, and, therefore, the arrangement of the burner should be such as to supply the gas to the points of ignition in an even flow free from eddies or any rotary motion.

To insure that all the gas shall be consumed to the best advantage, it is necessary that the proper proportion between the gas and air supply shall exist over the whole surface of the flame, and, therefore, that the gas shall be supplied in equal quantity at all the points of ignition.

The following details of construction have been adopted to put into effect the principles brought out above. To insure the existence of a low pressure at the burner tip the improved forms of flat flame burners are provided either with some form of governer, which maintains the pressure at the tip constantly at the proper point, no matter how much the pressure on the piping increases, or else with a "check," which is usually a metal, steatite or lava disk inserted in the burner pillar so as to cut off any flow of gas to the tip except through a hole in the disk, the area of which is smaller than that of the opening in the tip, the relation between the area of the opening in check and that of the opening in the tip varying with the pressure at which the burner is designed to be used, that is the higher the pressure the smaller the hole in the check for the same sized tip.

To produce a steady, even flow of gas without any swirling motion some burners have placed between the check and the tip a screen of fine wire gauze which breaks up any currents, and renders the flow of gas uniform throughout the whole area of the burner pillar, while others depend upon the steadying action produced by the large area of the burner pillar

above the check as compared with the area of the opening in the tip.

To secure an equal supply of gas to all parts of the flame, slit (batswing) burners are made with what is called a hollow top, by means of which the slit is kept at the same depth in all parts instead of being much thicker at the top than at the sides, as it would necessarily be if the top of the tip were left solid instead of hollowed out inside to conform with its shape outside. The effect of extra thickness at any place is that less gas passes through the slit at the thick place, and that consequently the conditions are not the same at all parts of the flame. A further improvement in this direction, introduced in some burners, consists in cutting the slit with a circular saw applied from above the tip and thus making it curved on the bottom instead of flat, as is the case when it is cut by sawing in the ordinary way. With the flat bottom slit some of the gas issues at right angles to the axis of the burner only to be folded back on the upper part of the flame by the upward draft of air caused by the heat of the flame, while with a curved bottom slit this effect is avoided as the gas issues in a direction along which it is free to travel without being turned aside, and the flame is thus kept of more even thickness throughout.

In Sugg's table top burners the effect of the upward rush of air in increasing the thickness of the lower edges of the flame is still further guarded against by forming a circular "table" immediately under the top of the tip, the projection of which deflects the currents of air and prevents them from rising vertically against the flame. (Trustees.)

11. Why are Bunsen or atmospheric burners used in gas cooking stoves and incandescent gas lights? Why are they not used in the ordinary cylindrical gas heating stoves and gas radiators?

Ans. Atmospheric burners are used in gas cooking stoves principally because the flames from such burners will not deposit soot upon the bottom of the cooking utensils when these utensils come into contact with the flame, as may frequently happen. Any such contact between the bottom of

a comparatively cold kettle or pot and a luminous flame will result in the setting free of a quantity of carbon in the form of soot, of which part will stick to the pot and part go off as smoke. Even if actual contact does not take place, the supply of air may become deficient when the top of the stove is covered with pots, and in this case the luminous flame would smoke. As the flame of the atmospheric burner does not need to draw as much oxygen from the atmosphere at the point of ignition as the luminous flame (since from one-third to one-half of the total amount required is already mixed with the gas) the combustion is more apt to be complete under such conditions, while even if it is incomplete no smoke will be given off from the flame.

The same reason holds for the use of the atmospheric burner for heating the mantles of incandescent gas lights. According to Prof. Lewes, carbon is deposited upon these mantles when the volumes of air mixed with a 16-candle coal gas is less than 2.2 times that of the gas. This ratio varies, of course, with the quality and character of the gas.

In the ordinary cylindrical heating stoves and gas radiators there is no danger of contact between the flames and any cold surfaces, and the air supply can always be satisfactorily arranged so as to produce complete combustion of the gas. There is, therefore, no danger of the formation of smoke from the luminous flame, and no choice between the luminous flame burner and the atmospheric burner on this ground. The amount of heat produced by the consumption of equal amounts of any gas is the same whether the gas is consumed in the atmospheric or luminous burners, provided the combustion is complete in each case. There is thus no advantage to be derived from the use of the atmospheric burner in these appliances, and the luminous burner is adopted as being simpler, more cheerful looking, capable of giving off more radiant heat, and not liable to lighting back with its accompaniment of incomplete combustion. (Trustees.)

12. What considerations would determine your choice between lime mortar and cement mortar for use in any given job of brick or stone masonry?

Ans. Since there are certain conditions under which lime

mortar will not harden and other conditions which are unfavorable to the durability of cement mortar, the main consideration in determining the choice between the two in any given case is that of the conditions to which the brickwork is to be subjected.

Lime mortar will not harden when cut off from access of air, or when exposed to water or to moist earth or air. It should, therefore, never be used in masonry work underground, in damp places and in thick walls, or to the middle of which the air cannot penetrate, all such masonry being laid with cement mortar. Under the head of damp places must be included the top four or five courses of all brick walls, which should always be laid with cement mortar, even though lime mortar is employed for the rest of the work.

Cement mortar, on its part, will not be durable when exposed to even moderate heat and so deprived of the moisture that is necessary to enable it to set and grow harder with age. It must, therefore, give place to lime mortar in that part of the brickwork of retort stacks, boiler settings and chimneys where it is not necessary to use fire clay on account of exposure to high heat.

When the conditions are such that either kind of mortar will set, the most important consideration in determining the choice between them is the strength that the masonry is required to have. Lime mortar is not as strong as cement mortar, and the latter must, therefore, be used whenever the strength requirements are greater than can be met by the former. It is also necessary to use cement mortar in masonry subject to vibration, such as the foundations of steam engines and other moving machinery, as in such masonry it is necessary to have the adhesion between the mortar and the brick or stone as strong as possible, and cement mortar is stronger in this respect than lime mortar.

Where lime mortar will set satisfactorily and is sufficiently strong for the requirements, the consideration that usually determines the choice is cheapness, and as a rule lime mortar is the cheapest. But by properly proportioning the amount of sand used with cement, it is often possible to make a mortar that is as cheap as lime mortar, and stronger. The cement

mortar can also be cheapened by mixing with it lime paste, and if the amount of this paste is not made greater than one-fourth of the combined amount of lime and cement, the resulting mortar will be stronger and better than lime mortar. But when there is not much difference between the cost of lime mortar and cement mortar without any admixture of lime, it is better to use the latter, since it is much more durable and will cost less for repairs. (Trustees.)

Sixth Series of Questións—Section of 1908—Practical Class—American Gas Light Association.

1. Is there any reason why gas coal that has been put into the coal shed of a gas works should not be be left there indefinitely if the supply is maintained so that it is not necessary to use it?

2. Describe the operation of a bench of coal gas retorts heated by a regenerative furnace, either half-depth or full-depth, including the care and operation of the furnace, stand-pipes and hydraulic main.

3. What is a by-pass? Give a description, illustrated with sketches, of a by-pass for two vertical, multitubular condensers.

4. Give a description, illustrated by sketches, of the ordinary dry centre valve for four purifying boxes, built to put three in action at one time. Show on the sketches the divisions of the seat and cover, and describe the action of the valve.

5. Give a description, illustrated by sketches, of a "King's" pressure gauge.

6. Why is it important to have the water-line in the drum of a station-meter always at the same level?

7. What is the common method of manufacturing sulphate

of ammonia, and what are the chemical reactions that occur in the process?

8. What are the products of the complete combustion of of each of the following substances?

   Carbon, C
   Carbon Monoxide, CO
   Hydrogen, H
   Benzene, C_6H_6
   Methane or Marsh Gas, CH_4
   Ethylene or Olefiant Gas, C_2H_4
   Ethane, C_2H_6
   Acetylene, C_2H_2

   Give in each case the weights of the products produced by the combustion of one pound of the substance, and in the case of gases give also the volumes of those produced from one cubic foot.

9. Give the heating power, in British Thermal Units, of a pound, and in the case of gases also that of a cubic foot, of each of the substances named in Question No. 8, and tell what you understand this expression "heating power" to mean.

10. How should a gas works be situated with reference to the level of the district to be supplied?

11. Give the ordinary formula for the rate of flow of gas through pipes, and calculate by means of this formula the amount of gas that can be delivered per hour through one-half mile of 8″ pipe with a loss of pressure of $\frac{6}{10}$″, the specific gravity of the gas being 0.65.

12. Describe the proper method of laying bricks in cement mortar.

(Answers to these questions are due July 1, 1906.)

Answers to Sixth Series of Questions—Section of 1908—Practical Class—American Gas Light Association.

The answer to Question No. 2 is included among the answers to the Eighth Series of Questions for the Section of 1907, and can be found on page 149 of this volume.

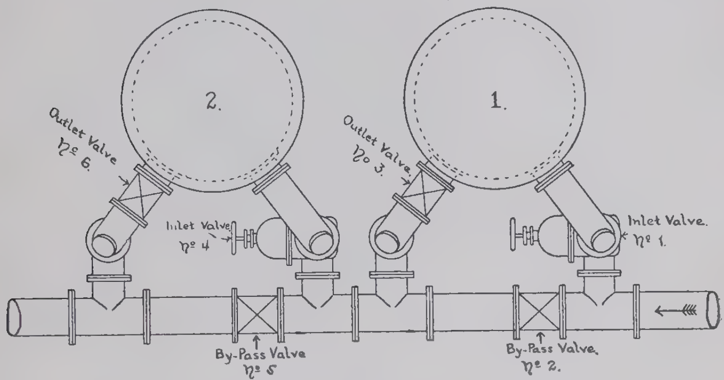
The answers to the other questions are as follows:

1. Is there any reason why gas coal that has been put into the coal shed of a gas works should not be left there indefinitely, if the supply is maintained so that it is not necessary to use it?

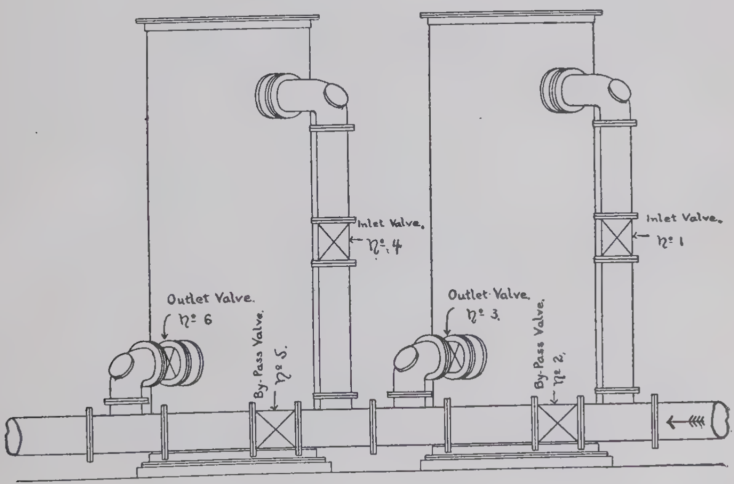
Answer. For any given gas works the answer to this question depends upon the character and qualities of the coal used. Some gas coals break up very badly when stored, the lumps becoming gradually converted into slack, and as this breaking up exposes fresh surfaces, as well as a greater surface in proportion to the volume, to the action of the air, and thus makes it easier for slow oxidation of the coal to take place, a comparatively rapid deterioration sets in and may continue until the value of the coal is practically destroyed. Under these conditions it is not advisable to keep coal in stock for any length of time, and a practice should be made of working out the oldest stock at regular and short intervals.

However, many of the gas coals used in this country, particularly those from Western Pennsylvania, do not depreciate to any great extent when stored, except on the surface of the pile, and even in this portion the loss is very small after the end of the first six months, so that such coal when stored in fairly deep piles, protected from the weather, will, even when stored for many years, suffer only a small total depreciation, the larger part of which takes place in the first year. When using coal of this kind, any stock that it is not necessary to use can be left in store indefinitely as far as loss in gas making value is concerned, since after having been stored for a year, the future depreciation on it will be much less than would be suffered by fresh coal stored in its place, and it is better to use the fresh coal, even if it is not possible to also make a saving

in cost of handling by working the fresh coal directly into the retort house instead of having to put it into and take it out of the shed.



By-Pass for Two Vertical Multitubular Condensers.



But even when the coal does not depreciate sufficiently to call for working out old stock, it is advisable to do this every few years and clean out the shed, for the purpose of checking

the accuracy of the coal account as carried on the books, since in most coal sheds it is impossible to secure an accurate check in any other way. If, however, the coal is stored in pockets, into one of which a known quantity has been put and allowed to remain undisturbed, or if the stock pile is kept entirely separate from the rest of the coal and not drawn upon, there will be no reason for not keeping indefinitely a stock of coal of the character spoken of in the preceding paragraph, except an emergency when no other coal can be obtained. (Trustees.)

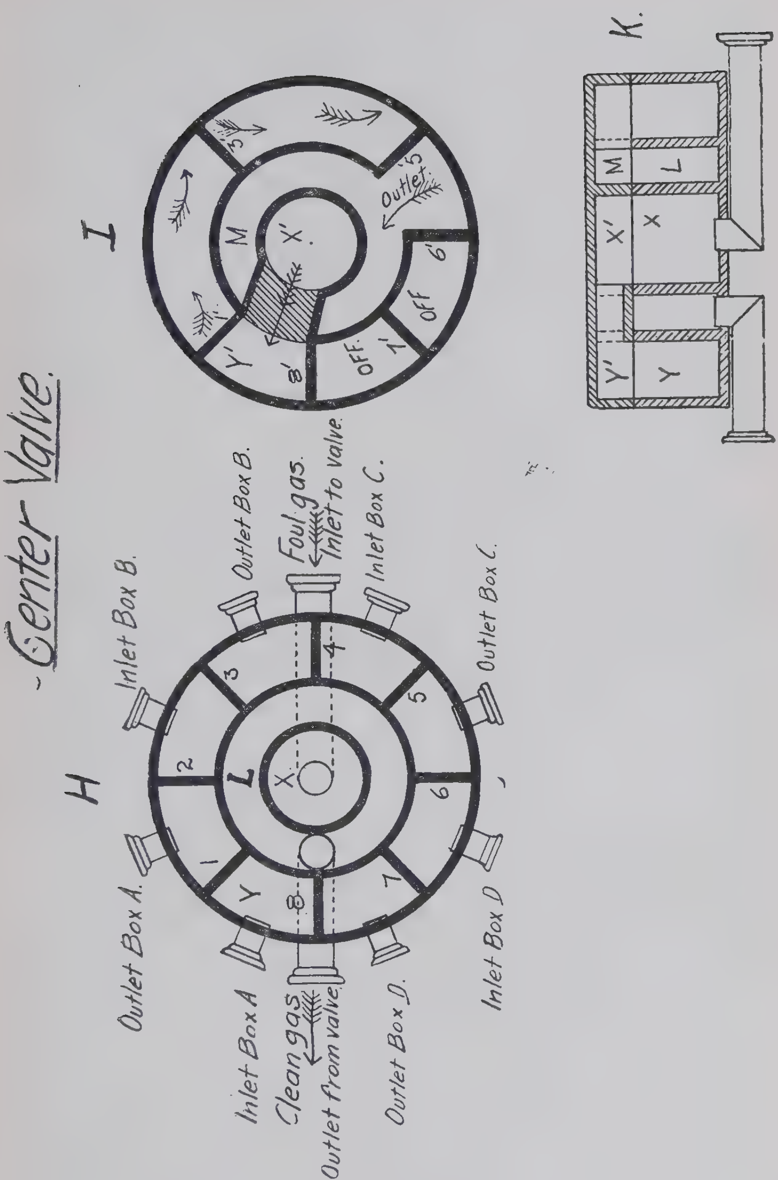
3. What is a by-pass? Give a description, illustrated with sketches, of a by-pass for two vertical, multitubular condensers.

Ans. A by-pass to any part of the apparatus of a gas works is a system of pipes and valves so arranged that by opening one or more valves, and closing others, the gas flowing may be directed either through, or past, that part of the apparatus concerned.

The preceding cut shows a by-pass for two vertical, multitubular condensers, so arranged that either one or both of them may be thrown out of action at any time without interfering with the working of any of the rest of the apparatus. When both condensers are in action, valves Nos. 1, 3, 4 and 6 are open and valves Nos. 2 and 5 are closed. To throw condenser No. 1 out of action while leaving No. 2 at work, valve No. 2 must be opened and Nos. 1 and 3 closed. Again, starting with both condensers at work, to leave No. 1 in action and throw out No. 2, valve No. 5 must be opened and Nos. 4 and 6 closed. When both condensers are to be thrown out at the same time, valves Nos. 2 and 5 must be opened and Nos. 1, 3, 4 and 6 closed. (Trustees.)

4. Give a description, illustrated by sketches, of the ordinary dry centre valve for four purifying boxes, built to put three in action at one time. Show on the sketches the divisions of the seat and cover, and describe the action of the valve.

Ans. The centre valve is a device whereby a set of four purifying boxes may be so operated that one box is thrown out of use for cleaning, the other three being in use, and the


Center Valve.
H
I
K.
Inlet Box B.
Outlet Box B.
Foul gas.
Inlet to valve.
Inlet Box C.
Outlet Box C.
Inlet Box D
Outlet Box D.
Outlet from valve.
Clean gas
Inlet Box A
Outlet Box A.
Outlet
1
2
3
4
5
6
7
8
L
X
Y
M
X'
Y'
1'
3'
5'
6'
8'
OFF
OFF

gas passing through them in sequence. The position of the cover on the body of the valve determines which box is out of use. The cut shows the construction of the valve, H being the body of the valve, I the cover, and K a vertical section through the cover and the body, showing the cover in place. The body of the valve has a solid bottom, and when the cover is removed is open at the top. The cover, which revolves on the body of the valve, has a solid top, but is open at the bottom, except for the part shown in shaded lines on the section I. The cut shows the cover as it would appear if the top plate were removed. If the cover I were placed over the body of the valve H, each in the position as shown on the cut, the space marked in cover Y^1 would exactly correspond with the space Y in the body of the valve. The course of the gas would then be as follows:

Entering the inlet to the valve, it would come into the centre space X, in the body of the valve. Having no other outlet, it would rise into X^1 of the cover. Its only outlet thence would be to Y^1 of the cover, thence to Y of the body of the valve, and thence through the inlet into box A. Passing through box A to its outlet, it would find its only possibility of escape to be into the space 1 of the body of the valve. The partition between Y^1 and 1^1 of the cover of the valve would be over the partition between Y and 1 of the body of the valve. The gas would, therefore, be compelled to rise from 1 of the body of the valve into space 1^1 of the cover of the valve. It could then, in the cover of the valve, pass over the partition between spaces 1 and 2 in the body of the valve, and down into space 2 of the body of the valve, which is connected with the inlet of box B. The partition between 1^1 and 3^1 of the cover would be over the partition between spaces 2 and 3 of the body of the valve. The gas then returning from box B, through its outlet into space 3 of the body of the valve, would find its only direction of further progress to be up into the cover of the valve into space 3^1, over the partition between spaces 3 and 4 of the body of the valve, and down into space 4 of the body of the valve, which is connected to the inlet of box C. Passing through box C and out of its outlet into space 5 of the body of the valve, it

finds its only direction of further progress to be into space 5^1 of the cover of the valve. But space 5^1 of the cover of the valve is shut off by the position of the cover on the body of the valve, from space 6 of the body of the valve, which is connected with the inlet of Box D. Therefore, the gas cannot reach the inlet of box D. But the space 5^1 of the cover of the valve is open to space M of the cover of the valve, which in turn is open to space L of the body of the valve (spaces M and L are annular rings surrounding the spaces X^1 and X). The gas then would pass from space M of the cover down into space L of the body of the valve. Space L of the body of the valve is directly connected with the clean gas outlet from the valve, and the gas, therefore, would pass, having no other means of egress, through this outlet.

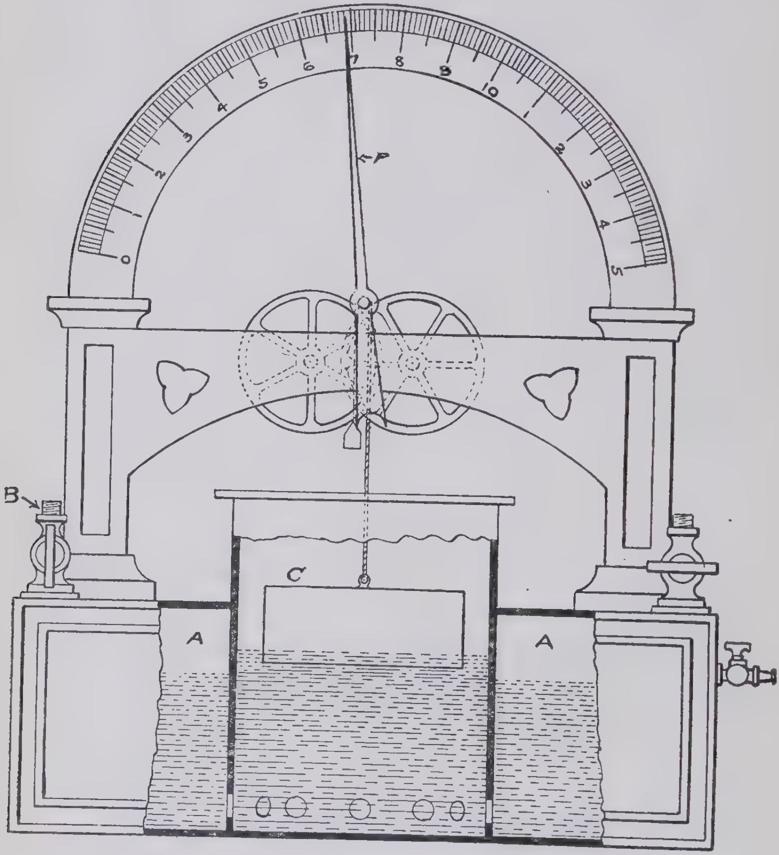
A little study of the cut will show that if the cover were revolved on the body of the valve until space Y^1 of the cover corresponded with space 2 of the body of the valve, which is the inlet of box B, box B would first receive the gas coming from the valve, and box D would be thrown into the series, box A being shut off. In this position of the valve, spaces 6^1 and 7^1 of the cover would be spaces Y and 1 of the body of the valve.

If the student will carefully cut out from the diagram of the cover the spaces 1^1, 3^1, 5^1, 6^1, 7^1, Y^1, X^1 and M, he will have left the lines showing the walls of the different compartments of the valve, and that part of the bottom of the cover which is solid, namely, the shaded part. If he will then apply this to the cut of the body of the valve, making the circular lines of one correspond with the circular lines of the other, he will be able, by moving the diagram of the cover, to get a better idea of the way in which the valve works, and of the positions which the cover must occupy in order to put one or another of the boxes off for cleaning. (Trustees.)

5. Give a description, illustrated with sketches, of a "King's" pressure gauge.

Ans. A "King's" pressure gauge consists of a hollow box divided into concentric compartments, of which the larger, A,

into which the gas is admitted through the inlet B, is closed to the atmosphere and the smaller, C, is open to the air at the top and is in communication with A at the bottom. When



KING'S PRESSURE GAUGE

both chambers are filled with water to a determined level and gas is admitted to A, the water in A is depressed and rises in C until the difference in levels is equal to the pressure of the gas on top of the water in A.

A small metal float rises and falls with the surface of the water in C, and its motion is communicated by a cord and pulley wheel to the pointer P. This pointer moves through an arc of a circle and indicates the pressure on a graduated semi-circular scale. The travel of the pointer for any given motion of the float depends on the size of the pulley wheel. The proportions of the apparatus, and therefore the travel of the pointer over the scale for any given rise of water in the chamber C, may be arranged to give the instrument almost any degree of sensitiveness; that is, to indicate small variations in pressure, smaller variations than could be easily read on the ordinary syphon gauge. King's pressure gauge is the invention of Mr. King, late of the Liverpool Gas Company. (Trustees.)

6. Why is it important to have the water-line in the drum of a station-meter always at the same level?

Ans. It is important to have the water-line in the drum of a station-meter always at the same level, and at the level at which it stands when the meter registers correctly, because any change of level will make a change in the number of cubic feet registered on the dial for each one thousand cubic feet passing the meter. If the water-line be lowered in the drum, more gas passes for a revolution of the drum, although the amount registered on the dial will remain the same. If the water-line be raised in the drum, less gas passes for each revolution of the drum. Therefore, if the water-line be below the correct level the meter registers less gas than passes and runs slow; if the water-line be above the correct level the meter registers more gas than passes and runs fast. (Trustees.)

7. What is the common method of manufacturing sulphate of ammonia, and what are the chemical reactions that occur in the process?

Ans. The manufacture of sulphate of ammonia depends on the chemical facts that all compounds or ammonia are decomposed when heated with an alkali, free ammonia being liberated, and that sulphuric acid combines with ammonia to

form sulphate of ammonia. The chemical changes involved may be represented as follows:

$(NH_4)_2CO_3$	+ $Ca(OH)_2$	= $CaCO_3$	+ $2H_2O$	+ $2NH_3$
Carbonate of ammonia	Hydrate of lime	Carbonate of lime	Water	Ammonia

and

$2NH_3$	+ H_2SO_4	= $(NH_4)_2SO_4$
Ammonia	Sulphuric Acid	Sulphate of Ammonia

In the operation as conducted by the intermittent system, the gas liquor is pumped into a still and heated by admitting live steam at the bottom of the still. On heating the mixture, free ammonia is disengaged, together with large volumes of sulphuretted hydrogen and other foul gases. When all, or nearly all, the free ammonia and that in the volatile compounds of ammonia have been driven from the liquor, cream of lime is added to free the ammonia from the fixed ammonia salts held in solution in the liquor. The acids of the salts combine with the lime, and the ammonia is liberated. The lime salts remain in the liquor. The ammonia and other gases leaving the still pass to a "saturator" containing sulphuric acid, through which they bubble. The ammonia is retained by the acid, forming a sulphate of ammonia, which crystallizes and settles out from the solution and is ladled out and dried. The foul gases after leaving the saturator are either burned, or absorbed by oxide of iron, in order to prevent a nuisance.

In the continuous system, a still similar to that employed for concentrating liquor is used, and the ammoniacal liquor is treated with steam and milk of lime as when it is to be concentrated. The gas escaping from the stills passes first through a baffle box for the removal of moisture, and then into the saturator as in the intermittent system. The waste gases from the saturator pass into the liquor heaters and impart their heat to the liquor flowing into the still, after

which they are either burned, or absorbed by iron oxide as in the intermittent system.

The continuous system is more economical, since the greater part of the heat in the waste gases is recovered, but the apparatus necessary is not as simple as that employed in the intermittent system. (Trustees.)

8. What are the products of the complete combustion of each of the following substances?

Carbon, C
Carbon Monoxide, CO
Hydrogen, H
Benzene, C_6H_6
Methane or Marsh Gas, CH_4
Ethylene or Olefiant Gas, C_2H_4
Ethane, C_2H_6
Acetylene, C_2H_2

Give in each case the weights of the products produced by the combustion of one pound of the substance, and in the case of gases give also the volumes of those produced from one cubic foot.

Ans. The products of combustion of the various substances named when burned in oxygen, O, are:

Substance.		Products of Combustion.
Carbon	C	Carbon Dioxide, CO_2
Carbon Monoxide	CO	" " "
Hydrogen	H	Water Vapor, H_2O
Marsh Gas	CH_4	Carbon Dioxide, CO_2, and Water Vapor, H_2O
Olefiant Gas	C_2H_4	" " " " " " "
Ethane	C_2H_6	" " " " " " "
Benzene	C_6H_6	" " " " " " "
Acetylene	C_2H_2	" " " " " " "

When substances are burned in air it is usual to consider the nitrogen, N, which is mixed in the air with the oxygen used, as being also a product of the combustion. To the products as given above should, therefore, be added in each case this nitrogen.

The weights of the products produced are found as follows:

When carbon is burned, each atom combines with two atoms of oxygen, forming carbon dioxide, CO_2. The atomic weight of carbon being 12 and that of oxygen being 16, the molecular weight of carbon dioxide each molecule of which contains one atom of Carbon, C, and two atoms of oxygen, O, is $12 + 32 = 44$. Hence, 12 lbs. of carbon will yield upon combustion 44 lbs. of carbon dioxide and 1 lb. will yield $\frac{44}{12} = 3.67$ lbs. of carbon dioxide. Since air contains 3.31 times as much nitrogen by weight as it does oxygen, the weight of nitrogen mixed in the air with the amount of oxygen, 2.67 lbs., required for the combustion of 1 lb. of carbon will be $2.67 \times 3.31 = 8.84$ lbs. The products of the combustion in air of 1 pound of carbon are, therefore, 3.67 lbs. of carbon dioxide and 8.84 lbs. of nitrogen.

The atomic weight of hydrogen is 1. Two atoms of hydrogen combine with one atom of oxygen to form a molecule of water vapor, the molecular weight of which is $2 + 16 = 18$. Two pounds of hydrogen thus yield upon combustion 18 lbs. of water vapor, and 1 lb. will yield 9 lbs. of water vapor. There will be mixed in the air with the amount of oxygen 8 lbs., required for the combustion of 1 lb. of hydrogen, $8 \times 3.31 = 26.48$ lbs. nitrogen. The products of the combustion in air of 1 lb. of hydrogen are, therefore, 9 lbs. of water vapor and 26.48 lbs. of nitrogen.

The combustion of marsh gas, or methane, CH_4, produces both carbon dioxide and water. A molecule of marsh gas contains one atom of carbon and four of hydrogen and has a molecular weight of $12 + 4 \times 1 = 16$. In every 16 lbs. of marsh gas there will thus be 12 lbs. of carbon and 4 lbs. of hydrogen, or each pound will contain 0.75 lb. of carbon and 0.25 lb. of hydrogen. It has been shown above that each pound of hydrogen burns to 9 lbs. of water vapor, and that each pound of carbon burns to 3.67 lbs. of carbon dioxide. Hence, the products of combustion of 1 lb. of marsh gas will be $0.75 \times 3.67 = 2.75$ lbs. of carbon dioxide and $0.25 \times 9 = 2.25$ lbs. of water. The amount of the oxygen drawn from the air is $2 + 2 = 4$ lbs., so the weight of nitrogen to be included with these products will be $4 \times 3.31 = 13.24$ lbs.

Name of Substance.		Weight of each Element in 1 lb. of Substance.			Weight of Products produced by the Combustion of 1 lb. of Substance, the Nitrogen mixed in air with the Oxygen required for combustion being considered as a product of combustion.			Volume of products produced by the Combustion of 1 cu. ft. of Substance, Nitrogen being included as before.		
		C	H	O	CO_2	H_2O	N	CO_2	H_2O	N
Carbon	C	1.000	......	......	3.67	......	8.84	......	......	......
Carbon Monoxide	CO	0.429	......	0.571	1.57	......	1.89	1.0	......	1.89
Hydrogen	H	......	1.000	......	......	9.00	26.48	......	1.0	1.89
Marsh Gas	CH_4	0.750	0.250	......	2.75	2.25	13.24	1.0	2.0	7.54
Olefiant Gas	C_2H_4	0.857	0.143	......	3.14	1.29	11.35	2.0	2.0	11.31
Ethane	C_2H_6	0.800	0.200	......	2.94	1.80	12.38	2.0	3.0	13.20
Benzene	C_6H_6	0.923	0.077	......	3.39	0.69	10.19	6.0	3.0	28.28
Acetylene	C_2H_2	0.923	0.077	......	3.39	0.69	10.19	2.0	1.0	9.43

The nature and weight of the products of combustion of the other hydrocarbons named can be determined in a similar manner to that employed above for marsh gas.

The volume of each of the products obtained by the complete combustion of one cubic foot of any given gas can be obtained very readily from the equation for the chemical reaction that takes place, since equal volumes of any gases contain equal numbers of molecules, or in other words the molecules of all gases have the same volume, and the volume in which gases combine with each other are proportional to the number of molecules of each gas which enter into the reaction.

In the case of hydrogen the reaction by which combustion takes place has the following equation, $2\ H_2 + O_2 = 2\ H_2O$. This shows that two molecules, or two volumes, of hydrogen combine with one molecule, or one volume, of oxygen to form two molecules, or two volumes, of water vapor. Therefore the complete combustion of 1 cu. ft. of hydrogen will require 0.5 cu. ft. of oxygen and will produce 1 cu. ft. of water vapor. Since air contains 3.77 parts of nitrogen to one of oxygen by volume there will be $\frac{3.77}{2} = 1.89$ cu. ft. of nitrogen mixed with the oxygen required, and the volume of the products of the complete combustion in air of 1 cu. ft. of hydrogen will be 1 cu. ft. of water vapor and 1.89 cu. ft. of nitrogen.

In the case of carbon monoxide the equation according to which combustion takes place is $2\ CO + O_2 = 2\ CO_2$, or 1 cu. ft. of carbon monoxide will combine with 0.5 cu. ft. of oxygen and form 1 cu. ft. of carbon dioxide. The volume of nitrogen mixed with the oxygen will be the same as in the case of hydrogen.

The volumes of the products of combustion of each of the other gases named in the question can be worked out in the same way.

For convenience the results of all the determinations both for weight and volume are given in tabular form on the preceding page.

9. Give the heating power, in British Thermal Units, of a pound, and in the case of gases also that of a cubic foot, of each of the substances named in Question No. 8, and tell what you understand this expression "heating power" to mean.

Ans.

	Per Pound	Per Cubic Foot.
Carbon, C	14,647	
Carbon Monoxide, CO	4,383	325
Hydrogen, H	62,100	328
Benzene, C_6H_6	18,094	3,732
Methane or Marsh Gas, CH_4	24,017	1,016
Ethylene or Olefiant Gas, C_2H_4	21,898	1,621
Ethane, C_2H_6	22,338	1,772
Acetylene, C_2H_2	21,856	1,502

The figures given by different experimenters for the heating power of gases vary, as do the figures for the weights of a cubic foot of the gases, and, therefore, the figures for the heating power per cubic foot vary also. Thus Newbigging, quoting from Letheby, gives the following figures for the heating power per cubic foot:

H	329
CH_4	996
CO	320
C_2H_2	1,251
C_6H_6	3,860

and the Committee on Education, quoting from Julius Thomsen, gave for some of the same gases:

H	325.5
CH_4	1,022.8
CO	324.7
C_2H_2	1,493.4

The values first given above are based on the determination of calorific power made by Berthelot as given in Poole's "Calorific Power of Fuels," and the weight of gases calculated from the weight of air as determined by Regnault and afterward corrected for slight errors.

By the calorific or heating value of a fuel is meant the total number of heat units that are developed by the complete

oxidation of all the combustible materials contained in unit weight or unit volume of the fuel. In the case of gases, the calorific value is ordinarily expressed in heat units per cubic foot. In the case of liquids and solids, the heating value is expressed in heat units per pound.

In the case of hydrogen and substances which contain hydrogen as one of their constituents, a distinction must be made between the gross or total heating power and the net or available heating power. The complete combustion of such substances produces water, which, while it is liquid at ordinary atmospheric temperatures, is a vapor at the temperatures at which the products of combustion escape under the ordinary conditions of the combustion of gases. To convert a pound of water from the liquid state to that of vapor at 212° F., 966 heat units are required. Since each pound of hydrogen burns to 9 pounds of water, there will be a difference, for each pound of hydrogen contained in the combustible gas, of $9 \times 966 = 8,694$ heat units, plus the number of heat units given out by 9 pounds of water in cooling from a temperature of 212° F. to that at which the condensed water leaves the apparatus, between the total heat of combustion as estimated by a calorimeter, in which the water is condensed to the liquid form and the heat required to vaporize it set free and measured, and the net heat or heat available, when, as in ordinary combustion, the water escapes in the form of vapor. If the temperature of the products of combustion is reduced to 60° F. by the calorimeter, the amount of heat given off by the water produced from 1 pound of hydrogen will be approximately $(212-60) \times 9 = 1,368$ heat units, and the difference between the gross and the net heating value of 1 pound of hydrogen will be $8,694 + 1,368 = 10,062$ heat units. If, therefore, the total heating power of hydrogen, as determined by the calorimeter, is 62,100 heat units, the net heating power, when the water escapes in the form of vapor at 212° F., will be $62,100-10,062 = 52,038$ heat units, and the net heating value per cubic foot will be 275 heat units. In the same way, knowing the percentage of hydrogen contained in any substance, the net heating value can be obtained by making the proper deduction from the gross value.

The figures given above are in each case those for the gross or total heating power. The net heating powers, figured according to the example given, are given below. In figuring on problems in combustion, in which fuels containing hydrogen are used under working conditions, the net heating powers should always be employed to arrive at the true results.

	Per Pound.	Per Cubic Foot.
Hydrogen, H	52,038	275
Benzene, C_6H_6	17,322	3,572
Methane or Marsh Gas, CH_4	21,502	910
Ethylene or Olefiant Gas, C_2H_4	20,461	1,515
Ethane, C_2H_6	20,336	1,613
Acetylene, C_2H_2	21,081	1,448

(Trustees.)

10. How should a gas works be situated with reference to the level of the district to be supplied?

Ans. "It may be taken as a rule that, other things being equal, the works should be situated below * * * * * the general level of the district supplied, as by that means advantage can be taken of the natural increase in the pressure of the gas as it travels from the lower to the more elevated parts." (King's Treatise.)

11. Give the ordinary formula for the rate of flow of gas through pipes, and calculate by means of this formula the amount of gas that can be delivered per hour through one-half mile of 8″ pipe with a loss of pressure of $\frac{6}{10}$″, the specific gravity of the gas being 0.65.

Ans. The ordinary formula for the rate of flow of gas through a pipe of any size under given conditions of length of pipe, specific gravity of gas and amount of pressure lost in the pipe is,

$$Q = 1350\sqrt{\frac{d^5p}{sl}}, \text{ or as it is often written, } Q = 1350d^2\sqrt{\frac{dp}{sl}}$$

in which

Q = the volume of gas passed per hour in cubic feet,
d = the diameter of the pipe in inches,
p = the pressure or head in inches of water,
s = the specific gravity of the gas, air being 1.000,
l = the length of the pipe in yards, and
1350 is a constant, the value of which has been determined by experiment.

In the problem given, the value of the different factors are:

$$d = 8 \qquad s = 0.65$$
$$p = 0.6 \qquad l = 880$$

hence substituting these values in the formula

$$Q = 1350 \times 64\sqrt{\frac{8 \times 0.6}{0.65 \times 880}} = 86{,}400\sqrt{\frac{4.8}{572}} =$$
$$86{,}400\sqrt{.00839} = 86{,}400 \times .0915 = 7{,}905 \text{ cubic feet.}$$

While it is necessary that the student should know the formula for the flow of gas and be able to apply it, in practice the results which have been obtained above by calculation can be obtained much more easily and quickly by the use of a Gas-Flow Computer, which is a device of the slide-rule type by means of which the size of pipe required to deliver any given quantity of gas under any given conditions of length of pipe, loss of pressure and specific gravity of gas can be read off by making the proper adjustments of the various scales marked on the computer. The use of one of these computers enables all problems similar to the one above to be rapidly and quickly solved. (Trustees.)

12. Describe the proper method of laying bricks in cement mortar.

Ans. In laying bricks in cement mortar, the joints should

be made as thin as it is possible to have them and at the same time give a uniform bearing of the bricks; all joints should be filled with mortar, and to insure adhesion between the mortar and the bricks, the bricks should be wet when put into the wall. Thinness of the joints is required, because the mortar is weaker than the brick, and a thick joint is weaker than a thin one, even under the best conditions, and also because in outside walls the mortar in thick joints is more exposed to deterioration from the action of the weather.

If the joints are not well filled, the strength of the wall is obviously reduced. To secure thoroughly filled joints, the bricks "should not be merely *laid*, but every one should be rubbed and pressed down in such a manner as to force the mortar into the pores of the bricks and produce the maximum adhesion. For the best work, it is specified that the brick shall be laid with a 'shove joint,' that is, that the brick shall be first laid so as to project over the one below and be pressed into the mortar, and then be shoved into its final position.

"Since brick have great avidity for water, it is best to dampen them before laying. To get the greatest strength the mortar should have only enough water to make a stiff paste—the less water the better. If the mortar is stiff and the brick dry, the latter absorb the water so rapidly that the mortar does not set properly, and will crumble in the fingers when dry. Neglect in this particular is the cause of most of the failures in brick work. Since an excess of water in the brick can do no harm, it is best to thoroughly drench them with water before laying. Wetting the brick before laying will also remove the dust from the surface, which otherwise prevent perfect adhesion." (Baker's "Masonry Construction.") (Trustees.)

Tenth Series of Questions—Section of 1907—Practical Class—American Gas Light Association.

1. What are the advantages derived from heating the oil used in a carburetted water gas apparatus before it is admitted to the carburetter?

2. Give a drawing of one length of hydraulic main to be used with the bench of retorts illustrated in the Trustees' Answer to Question No. 4, Ninth Series. This drawing should show all the dimensions of the main, and also the arrangements for running off the tar and ammoniacal liquor, and for cleaning the main, while in operation, from any heavy tar that may accumulate in it. State in writing the reasons that determine the choice of the dimensions that you give.

3. What points are to be observed in the design of a boiler setting in order to make it possible to obtain good efficiency of operation?

4. Name, in the order in which the gas should be subjected to them, beginning at the outlet of the hydraulic main, the various steps to be taken in the condensation and purification of coal gas, and state the temperature that should be possessed by the gas at the beginning and end of each step.

5. What is the meaning of the term horse power as applied to steam engines? What is indicated horse power? What is effective horse power?

6. Describe the proper treatment of iron oxide from the time it is taken out of the box for revivification until it is again returned to the box.

7. What is meant by the tension of a vapor? By maximum vapor tension?

8. Describe a system of records by means of which full information regarding the location, size, etc., of street mains can be economically filed in such shape as to be available for quick and ready reference.

9. What are the respective advantages of wet and dry meters for use as consumers' meters?

10. A complaint of a leak of gas is received from a consumer. Assume that it is your duty to investigate the complaint and tell how you would handle the job.

11. What relation, if any, is there between the calorific value of an illuminating gas and its illuminating value when consumed in a standard luminous flame burner?

12. Describe the method of building up the wall of a concrete gas holder tank and the precautions to be observed to insure its being water tight.

(Answers to these questions are due August 1, 1906.)

Answers to Tenth Series of Questions—Section of 1907—Practical Class—American Gas Light Association.

The answer to Question No. 6 is included among the answers to the Eleventh Series of Questions for the Section of 1906, and can be found on page 117 of this volume.

The answers to the other questions are as follows:

1. What are the advantages derived from heating the oil used in a carburetted water gas apparatus before it is admitted to the carburetter?

Answer. The advantages derived from heating the oil used in carburetted water gas apparatus before it is admitted to the carburetter are a saving in coal, if the oil is heated by heat that would otherwise be wasted, and an increased efficiency in the use of oil.

All the oil run into the carburetter must be raised from the temperature at which it enters, to that existing in the carburetter, by means of heat supplied from the checker-brick, after having been received by them from the blast gases during the preceding blow. The lower the temperature at which the oil enters, the greater the quantity of heat that must be given out by and supplied to the checker-brick, and, therefore, the greater the quantity of combustible blast gases required to be produced and the greater the consumption of coal in the generator. Any heating of the oil before it enters the carburetter thus causes a corresponding decrease in the amount of

coal used in the generator and if the otherwise waste heat in the gas leaving the apparatus is utilized for the purpose, the result is a clear gain in economy of fuel.

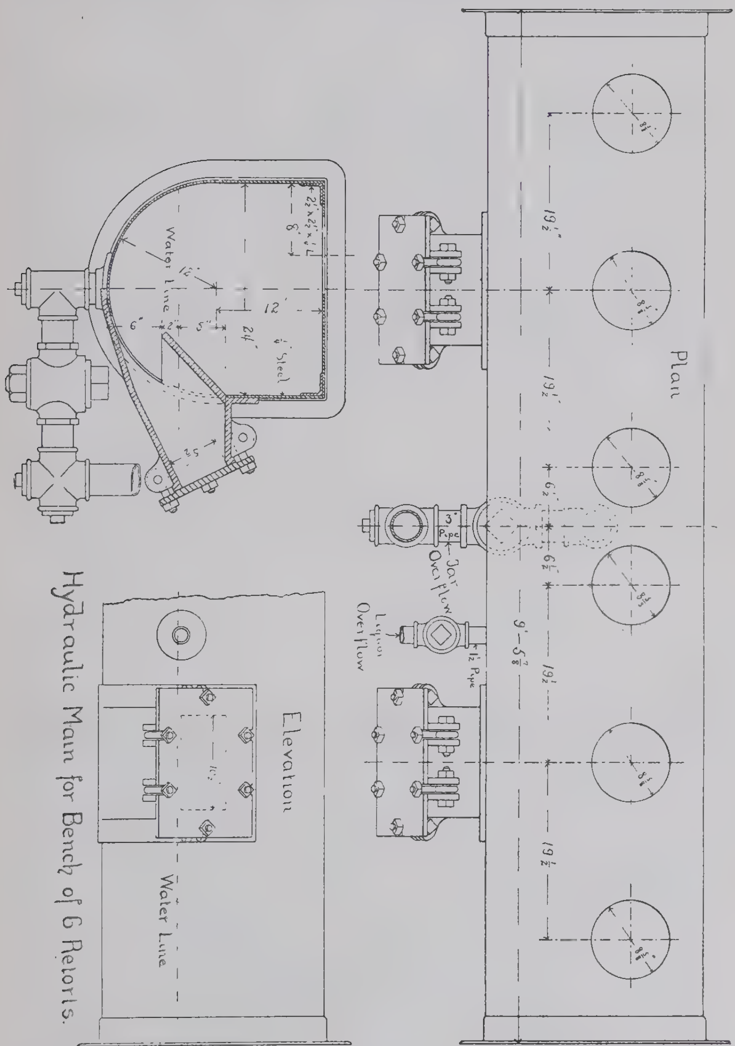
The work of heating, vaporizing and gasifying the oil lowers the temperature of the checker-brick in the carburetter and superheater continuously from the beginning to the end of a "run," and this cooling effect is naturally greatest at the top of the carburetter where nearly all of the heating and evaporating of the oil is done. It is evident that, to obtain the best results, the temperature of the checker-brick should be kept throughout the run, as nearly as possible, constant and at the point best suited to the oil being used, and that any variation of the temperature from this point means a change in the conditions under which, and, consequently, probably a change in the efficiency with which, the oil is being gasified. Preheating the oil lessons this variation in temperature and therefore enables the oil to be gasified more efficiently. It would seem that when the oil is heated to a high temperature, the checker-brick in the carburetter and superheater should be kept at a lower temperature than when cold oil is used, in order to prevent the overheating and excessive breaking down of the heavy hydrocarbons derived from the oil.

It should be noted however, that, on account of its partial vaporization, oil when heated to a high temperature is harder to spray evenly into the carburetter and that, consequently, some engineers prefer to use the oil without preheating it. (Trustees.)

2. Give a drawing of one length of hydraulic main to be used with the bench of retorts illustrated in the Trustees' Answers to Question No. 4, Ninth Series. This drawing should show all the dimensions of the main, and also the arrangements for running off the tar and ammoniacal liquor, and for cleaning the main, while in operation, from any heavy tar that may accumulate in it. State in writing the reasons that determine the choice of the dimensions that you give.

Ans. The accompanying cuts show a plan, section and part elevation of a length of hydraulic main made for the bench of

retorts illustrated in the Trustees' Answer to Question No. 4, Ninth Series, and also details of the liquor and tar overflows.



Hydraulic Main for Bench of 6 Retorts.

The body of the main is made of ¼″ steel, and the cleaning pockets of cast iron, these pockets being bolted, or riveted, to

the body at the proper places. They are made, as shown, with their inner upper edges sealed below the liquor in the main so that the covers can be taken off at any time and the main cleaned without interfering with the operation of the retorts.

The bottom of the pockets comes up on a gentle slope from the lowest point of the main, and there is nothing to interfere with getting the heavy tar out very easily when it is necessary. The covers of the pockets are fastened down by swinging bolts, and can be taken off and put back again very quickly and readily.

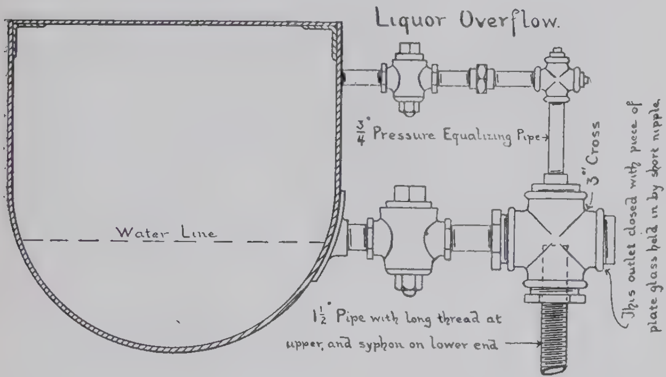
The liquor and tar overflows are made entirely of ordinary pipe and fittings, except that it is well to have the stop-cock on the tar overflow made with the opening in the plug round and the full size of the pipe, which requirement is not fulfilled by the ordinary iron stop-cock. At the same time these overflows are adjustable over a height of 3 in. or 4 in. By setting a piece of plate glass in the outer horizontal outlet of the cross, into the bottom outlet of which is screwed the adjustable pipe, a means is afforded of observing the depth of the seal at all times.

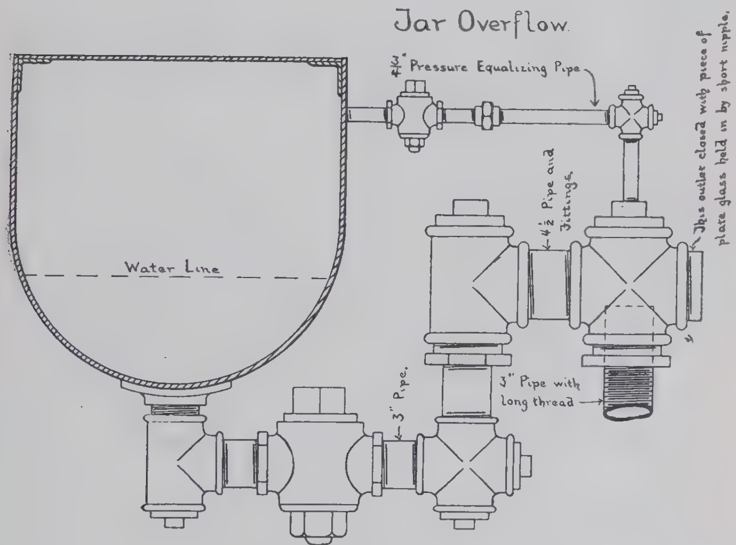
No gas take-off is shown. A short extension piece bolted on either end of the main, as may be most convenient, is provided for this.

The reasons by which the general dimensions of the main are determined are as follows: The over-all length of each section must be just enough less than the distance between the middle lines of the partition walls of the bench, to allow for the thickness of the gasket required between two sections. The distance between the middle lines of walls being 9 ft. 10 in. in the given case, the main is taken as 9 ft. 9¾ in. long. The width is determined by the area of liquor which it is required to have outside the dip-pipes, and this depends upon the following considerations. It is necessary that the dip-pipes should remain sealed when the retorts are open, and the surface of the liquor in the dip-pipes is subjected to atmospheric pressure, even when the pressure in the main is at the highest point it is likely to attain under the conditions existing in any given works. The unsealing of the dip-pipes,

Hydraulic Main.

Details of Liquor and Jar Overflows.





when the water is at the proper level, can only be brought about by the forcing up into them of a volume of water equal to the area of the liquor in the main outside of the pipes, multiplied by the distance from the normal surface of the liquor to the lower edges of the dip-pipes, that is, of a volume equal to the surface area of the liquor multiplied by the normal depth of seal. The depth of seal is usually taken as 1 in., and it is considered that the highest pressure that will have to be provided for will be about 10 in. The width required in the given case is therefore found by this calculation. Six dip-pipes, having an internal diameter of 7 in. and an external diameter of 8¼ in., will have a combined internal area of 291 square inches, and a combined external area of 321 square inches. There being liquor to the depth of 1 in. in the dip-pipe under normal conditions, if the area of the main outside the dip-pipes is nine times the total internal area, a pressure of 10 in. will be provided for. The area outside the dip-pipes must, therefore, be at least $9 \times 231 = 2079$ square inches, and the total area of the surface of the liquor should be $2079 + 321 = 2400$ square inches. As the length of the main is 9 ft. 9¾ in. = 117.75 in., its width at the water line must be $\frac{2400}{117.75} = 20.38$ in. This width at the water line is secured by making the main 24 in. wide and of the shape shown. If a greater pressure had to be provided for it would be necessary to make the main wider. By putting between each two lengths of main a partition extending 4 in. or 5 in. above the normal water line, and thus forming a separate water compartment for each bench, while leaving the gas-way open between the different lengths, the dip-pipes on any bench that is idle can be given a heavier seal than those that are working, and thus be made safe against a higher pressure. (Trustees.)

3. What points are to be observed in the design of a boiler setting in order to make it possible to obtain good efficiency of operation?

Ans. The chief points in the design of a boiler setting which affect efficiency of operation are the area of grate surface, the size of combustion chamber, ease of getting at all parts of the heating surface for purposes of cleaning, and the

prevention of loss of heat and of influx of air through the walls of the setting.

The proper area of grate surface depends upon the character of the fuel and the area of heating surface of the boiler. The grate must be large enough to burn the quantity of fuel required without the necessity for an excessive draft, but not so large in proportion to the heating surface that the products of combustion will, owing to contact with an insufficient amount of boiler surface, pass out to the chimney at too high a temperature. Knowing the amount of steam that the boiler will be required to furnish and the weight of water that can be evaporated by a pound of the fuel to be used, the grate surface can be figured on the basis of a consumption of 10 lbs. of anthracite and 15 lbs. of bituminous coal per square foot per hour. This will give the largest area that will be required, which can be reduced, if found advisable, by bricking over part of the grate near the walls. The proportion between grate surface and heating surface should, according to Mr. Geo. H. Barrus, be as 1 to 36 with anthracite coal and as 1 to 45 to 50 with bituminous coal when the rate of combustion is from 10 to 12 lbs. of coal per square foot of grate surface per hour. If the rate of combustion is to be higher, there must be more heating surface in proportion to grate surface. The proportions given are those which were found in the boilers which showed the best efficiency out of a great number tested by Mr. Barrus.

The combustion chamber, that is, the space above the grate between it and the boiler, should be made large enough to enable the combustion to be completely finished before the products come in contact with the boiler. The temperature of the outside surface of the boiler shell is only a very little higher than that of the water in the boiler and much below that required to carry on the combustion of the gaseous products of the partial combustion of the fuel, and, therefore, if these products come into contact with the boiler while still unconsumed their temperature is reduced and combustion stops, with a consequent waste of fuel. As bituminous coal gives off more gaseous products that are combustible, than either anthracite coal or coke, a larger combustion chamber is

needed for the first than is required for the others. As the horizontal area of the combustion chamber is restricted by the size of the boiler, the increase in volume can only be obtained by an increase in the height, that is, in the distance between the top of the fire and the lowest point of the boiler. With anthracite coal this height may be made as small as 18″, but with bituminous coal it must be made much greater, a height of four or five feet being required with coal giving off a large proportion of volatile matter. The necessity of providing sufficient room to enable the combustion to be fully completed before the products are cooled below the temperature of ignition is not always understood, but where this is not done the efficiency of the boiler suffers.

When the setting is not built so that all parts of the heating surface can be easily reached for cleaning, the parts that cannot be reached will soon become coated with soot and flue dust and rendered very inefficient.

To prevent loss of heat and influx of air through the walls of the setting, the outer walls should be made at least 24″ thick, with a 2″ air space in the middle of the wall, and where two or more boilers are set in a battery, each division wall should be in two parts, with a half-inch space between them. This prevents radiation and also allows for expansion and contraction, and thus reduces the liability of the walls to crack, a liability especially great in the case of a solid division wall, with the boiler on one side let down while that on the other is under fire. The setting should also be well braced with buck-stays and tie-rods made strong enough for the work they are called upon to do. The part of the boiler above the setting should be covered with a plastic non-conducting material in a layer 2½″ thick. Such a covering is a better non-conductor of heat and also lighter than the brick arch very generally employed, besides allowing greater freedom of access to the boiler in case of a leak. (Trustees.)

4. Name, in the order in which the gas should be subjected to them, beginning at the outlet of the hydraulic main, the various steps to be taken in the condensation and purification of coal gas, and state the temperature that should be possessed by the gas at the beginning and end of each step.

Ans. There is a difference of opinion among engineers as to the first step to be taken in the condensation and purification of coal gas as it leaves the hydraulic main. While there is no question that the heavy tar should be removed before the temperature of the gas has fallen below 100° F., it is claimed by some engineers that better and more uniform results are obtained from the tar extractor when the gas reaches it at a uniform temperature between 110° and 120° F. than when its temperature is allowed to be above this, and they therefore advise a preliminary cooling, under control, for the gas, which leaves the hydraulic main at temperatures varying from 140° to 130° F., before it goes into the tar extractor. Other engineers take the gas through the tar extractor with only such cooling as it gets in the pipe through which it passes, and some even go so far as to jacket this pipe to prevent any loss of heat. In most cases of recent construction the preliminary cooling has been adopted, and is effected by the use of an annular atmospheric condenser, provided with means for regulating the amount of air flowing through the central opening, and, consequently, the amount of cooling suffered by the gas.

As is implied by what is stated above, the next step is the removal of the heavy tar by some form of tar extractor which acts by friction and without affecting the temperature to any appreciable extent, and the gas should enter this piece of apparatus at a temperature not lower than 100° F. and leave it with a loss of not more than two or three degrees.

After passing through the hot tar extractor, the gas is ready to be cooled gradually in water condensers by which its temperature should be reduced to 60° F. In cold climates there would not seem to be any objection to, and there might very possibly be an advantage in, cooling below this point, since the gas is certain to be cooled below it in the holders and street mains, and the gradual cooling that can be given in the condensers is less harmful than a sudden cooling later.

After being cooled, the next step is the removal of the ammonia by means of washers or scrubbers, or a combination of the two, the temperature being kept during this process at as near 60° as possible.

The final step in the purification of the gas is the removal of the sulphuretted hydrogen and, when advisable, of the carbonic acid contained in it. This removal can be effected most economically at a temperature of from 100° to 110° F. and the gas should be heated up to this point at the inlet to the purifiers. This heating can be done by steam either allowed to mix with the gas, or, preferably, passed through a coil of pipe in the bottom of the first box in the series.

As will be noticed, no mention of the exhauster is made above since it is not, strictly speaking, part of the condensing and purifying apparatus, all of which will work in exactly the same manner and at the same temperatures whether an exhauster is used or not. (Trustees.)

5. What is the meaning of the term horse-power as applied to steam engines? What is indicated horse-power? What is effective horse-power?

Ans. Horse-power, as applied to steam engines, is the unit of power by which is measured the quantity of work done, or of energy transformed, in the unit of time. In other words, it is a measure of the rate at which work is performed. Its value in British units is

550	foot-pounds	per	second,	or
33,000	"	"	"	minute, or
1,980,000	"	"	"	hour.

Indicated horse-power is the work, expressed in horse-power, performed per minute by the steam upon the piston of an engine and is calculated from the mean effective pressure per square inch of piston shown by an indicator diagram, or diagrams, taken while the engine is at work. It is therefore the work done by the steam in the cylinder of a steam engine.

Effective horse-power is the work transmitted to the main shaft of an engine and thus made available for performing useful work. It is usually measured by means of a brake, and is therefore often called "brake horse-power." It is of course always less than the indicated horse-power by the amount of the losses, chiefly frictional, in the engine. (Trustees.)

7. What is meant by the tension of a vapor? By maximum vapor tension?

Ans. By the tension of a vapor is meant the pressure exerted by the vapor against the walls of a vessel containing it or in opposition to any other restraining force. The pressure is due to the force with which the molecules of the vapor, as they move more or less freely along straight lines, strike against the walls of the vessel or move in a direction opposite to that of the force.

The tension of a vapor is also the measure of the extent to which it can resist compression, and the maximum vapor tension, sometimes called simply the vapor tension of a substance, is the heaviest pressure which it can resist, when in contact with some of the liquid from which it is produced, that is, when saturated, without a portion of the vapor being condensed back to the liquid form. For any given vapor this maximum tension varies with the temperature, being greater as the temperature is higher.

At the same temperature each vapor has its own maximum tension, the vapors of liquid boiling at low temperatures having greater tensions than those of liquids boiling at high temperatures. High "vapor tensions" therefore correspond to low boiling points, and, conversely low "vapor tensions" to high boiling points. (Trustees.)

8. Describe a system of records by means of which full information regarding the location, size, etc., of street mains can be economically filed in such shape as to be available for quick and ready reference.

Ans. The question of street main records naturally divides itself into two parts, the obtaining of the data and the recording of them in a convenient, accessible shape.

On new work the obtaining of the data is a very easy matter, although it is often overlooked. As each piece of main is laid, measurements showing the line on which it is run, its depth below the surface of the street, the location of all fittings, and that of at least one bell on each block should be made and recorded. The measurements showing the line

along which the main is run are generally taken from the nearest curb, but for unpaved streets it is probably preferable to take them from the property line, as this is less apt to change. The measurements along the line itself giving the location of fittings and of the bells, should be made from a zero point, such a point being adopted for each city block. One of the property lines of the intersecting street makes a good zero point, care being taken to take the corresponding line for each block along each street, and as far as possible for every one of a number of parallel streets, and to make all measurements in the same direction. Thus, on streets running north and south, the zero point should be either the south line or the north line of the intersecting street in each case, and not the south line in some cases and the north line in others. If no cut lengths are put in between intersections, except immediately at the fittings, it is only necessary to locate the bell at which the full lengths begin and to make a note of the normal distance between bells. If a cut piece is required away from a fitting, the bell at which the full lengths again begin should be located. This information as to the location of bells is valuable when the work of barring for leaks is to be undertaken, especially where the mains to be barred over are under pavement.

To make it easier to report the information noted above as being necessary, the person whose duty it is to obtain it should be provided with copies of a special form upon which it can be entered in writing as well as by means of sketches. Different forms are used by different companies, some using simply a card 5″ x 8″ on which a heading is printed as shown and the remainder section-lined, that is, divided by light blue lines into squares, to make it easy to make sketches upon it, while others use cards on which, in addition to the heading, is printed a

SKETCH CARD OF STREET MAIN CONNECTIONS

.... Side .... Street

From .... To .... St.

No. .... Date .... 19....

Commenced .... 19 ...   Finished .... 19....

diagram of a block with the two intersecting streets. The latter form does not meet the case of intersections at angles greater or less than a right angle. With either style of form one is filled out for each block of pipe laid and is used to post the information on the permanent record.

VALVE RECORD

Nearest House No. .... St.

.... Date .... 190...

Location .... Feet .... Ins. .... of .... Line

.... Ft. .... Ins. .... of .... Line of .... St.

SIZE OF MAIN .... Depth to top .... Ft. .... Ins. .....

.... Ft. .... Ins. .... of .... Line ....

Kind of Valve ....

Opens to the ....

Remarks ....

.... ○ ....

Signed ....

DRIP RECORD

Nearest House No. .... St.

.... Date .... 190..

Location .... Feet .... Ins. .... of .... Line

.... ft. .... ins. .... of .... Line of .... St.

SIZE OF MAIN .... Depth to Top .... Ft. .... Ins. ....

.... Ft. .... Ins. .... of .... Line ....

Style of Drip ....

Remarks ....

....

.... ○ ....

Signed ....

STREET MAIN INFORMATION CARD

Nearest House No. .... St.

Nature of Work .... Date .... 190 ..

Size .... Depth to Top ...... Ft. .... Ins. ....

Distance .... Ft. .... Ins. .... of .... Line

Drips Towards ....

Kind of Soil ....

Remarks ....

....

....

....

Sign here ....

In the case of old work for which there are no records, every street opening made by the company, and all those made by others that are noticed, should be taken advantage of for the purpose of securing the information desired. For this purpose the foreman of every service gang and any other employees, including the superintendent, who are apt to come across such openings, should be equipped with small cards, printed as shown, on which to enter the measurements taken. If an intersection is exposed a sketch can be made on the back of the card. Information as to drips and valves can be put as secured on other cards, printed as shown, and, if desired, sketches of connections to them can be made on the back of the cards. These drip and valve cards should also be used to report the location of drips and valves put in during the course of new work.

When these cards are handed in, either to the record department in the case of a large company, or to the superintendent where the company is so small that this official is also the draughtsman, the information contained in them should be posted to the street main maps, and the cards then filed for future reference. The filing is often done according to geographical location, the streets being arranged alphabetically,

and the cards for each street in the order of the street numbers. It may also be done by giving a number to every city block or every section of road in the territory, these numbers being marked on a wall map used as an index map, and filing all cards referring to any city block or section of road under the proper number, sub-numbers being used when two or more cards are filed for any block. Thus, if the block were No. 100, the first card would be No. 100-1, the second No. 100-2, and so on. When information is wanted for any locality, the number is found from the index map, and it is very easy to find the card in the file. For comparatively small new systems and where the street numbers do not run by blocks, and, consequently, do not afford any indication of the exact location on the street of any number, or where there are no street numbers, as in small towns and along country roads, the block number system is the best. For very large, old systems with no records there is not much choice, and the geographical filing does not involve any preliminary work in assigning block numbers.

A map showing the whole territory on one sheet, if possible, and on not more than two or three sheets at the outside, should be made on tracing cloth. A good scale for this map is 300 feet to the inch. If the blocks are to be numbered, the numbering should be done on this tracing. Except for the names of the streets and the block numbers, all of which should be put inside the property lines and not in the spaces showing the streets, the tracing is to be left unmarked, and black or white prints are to be made from it for use as maps. On one such print every street main in the system should be entered, the different sizes being distinguished either by the use of different colored inks, or of different combinations of dots and dashes in the same color. When using different colors it is well to work from lighter to darker colors as the size increases, so that when an old main is replaced by a larger one, the darker cover will cover the lighter one without any need of making an erasure. This map will merely show the fact that at a certain location there is or is not a gas main, and if the main is there it will give its size, but it will not show any details of location or construction. If desired, similar maps

can be made to show trunk mains, nothing smaller than 8 inch being put on, and the general location of drips and syphons and valves, a separate map being used for each special purpose.

For recording details an "insurance map" of the territory should be bought whenever one is available. These maps show all settled parts of a city on a scale of 50 feet to the inch and the unsettled portions on a scale of 100 feet to the inch, and consist of a number of separate sheets bound in book form, each sheet covering several squares. On them are shown all buildings, and when they are purchased from the company that publishes them, arrangements can be made to have them kept posted as to new buildings and changes in old buildings. They sometimes also show water mains, and in ordering them it should be stipulated that water mains are not to be shown on the set furnished. If no insurance map or other already prepared large scale map be available, a special large scale map in sheets will have to be made to take its place. On whichever is used should be shown the size and detail of every street main. The sizes may be marked in the same way as on the small scale map, or all the mains may be put in in solid black lines and the size indicated by figures and the use of lines of different thicknesses. The distance of the pipe from the property line and the positions of all fittings, drips, valves, sleeves, etc., should be located by writing on the map the proper dimension lines, the scale being large enough to permit this to be done with clearness in the case of all distribution systems, except those in a few of the very large cities where the underground situation is such as to make it necessary to use a large number of fittings, closely spaced. Rubber stamps of the proper shapes can be used for marking the various fittings to facilitate the work. With cards made out and filed and maps drawn as described above, there will be no trouble in finding quickly and easily any information as to the street main system that is desired, and the information will have been obtained and filed as economically as it is possible to do it.

Articles which contain good ideas on the subject of street main records and maps will be found as follows: American Gas Light Journal, Volume LXVI, page 481; Vol. LXX, page 482; Vol. LXXIV, page 449, and Progressive Age, Vol. XVII, page 128; Volume XIX, page 114.

9. What are the respective advantages of wet and dry meters for use as consumers' meters?

Ans. The principal advantages of well-made wet meters for use as consumers' meters are the accuracy with which they register the volume of gas passing through them and their simplicity of construction, by reason of which they are able to maintain this accuracy of registration over long periods of time without the necessity of being brought into the shop for repairs.

When made with a compensating device, which will, within limits, automatically keep the water line correct in spite of the evaporation of the water in the body of the meter, and with an anti-tilting valve which will shut off the gas in case an attempt is made to tilt the meter in order to cause it to pass gas without registration, a wet meter will measure with great accuracy the gas delivered through it, and as there are no diaphragms nor slide valves to get out of order, by drying out or by friction, it does not require the periodical testing that is necessary to make certain that a dry meter is measuring correctly. On the other hand, the wet meter requires more frequent visits by the employees of the gas company, in order to maintain a sufficient quantity of water in the meter, and to see that it is properly leveled.

The great advantage of dry meters as compared with wet meters for use as above is their freedom from the danger of freezing to which wet meters are liable in cold climates. A second advantage derived from the absence of water is the reduced danger of the collection of water in any trapped places in the house-piping, with the consequent greater freedom from the jumping or complete shutting-off of the lights on the far side of such places.

Other advantages of dry meters are smaller first cost; greater ease of setting on account of their lighter weight, size for size, and of their not requiring to be so accurately leveled; greater ease of removing on account of their lighter weight, and of the freedom from the difficulty of disposing of the gas-saturated water which is experienced with the wet meters; freedom from risk of the nuisance which may occur through escape of gas, and possibly the spilling of water saturated with

gas, when the water in wet meters is replenished, and, consequently, the possibility of being put in places where wet meters would not be wanted by consumers.

In a general way, the advantage of the wet meter is, that it will, with moderate attention, which does not require the meter's removal from its position, continue for a long space of time, to measure gas accurately, and the advantages of the dry meter, are its cheapness in first cost, its freedom from freezing, and its convenience, in spite of the fact that it requires periodical removal for testing and repairs. The choice between them is determined mainly by comparing the cost of maintaining a high average of accurate registration with the two types. In cold climates, the freezing of the water in wet meters increases so greatly the inconvenience of dry meters, as to make the use of the latter more economical; but in warm climates it may easily happen that the use of wet meters will be more economical than that of dry meters. (Trustees.)

10. A complaint of a leak of gas is received from a consumer. Assume that it is your duty to investigate the complaint and tell how you would handle the job.

Ans. The person investigating a complaint of a leak of gas should, after reaching the house and making known his identity and errand, obtain from the occupants all the information possible as to the size and location of the leak. If they can give definite information it can be acted upon, but failing such information a thorough examination of all the fixtures and piping will be required.

When the leak is noticable in one room only, the keys of the fixtures in that room should be examined to see that all are shut-off and that there are no leaks around them. Finding the keys tight, the joints between different parts of the fixtures and between these and the pipe outlets should next be investigated. In every case the examination should be made by smelling at the suspected points, or, in case the sense of smell is deficient, by means of soapy water. In no case should a light be used, as it is dangerous. Moreover, even very small leaks can be located by smelling or by soapy water more

quickly and accurately than by the use of a light. Never strike a match or attempt to light a leak after it has been found.

Where the smell of gas is noticable more or less all over any one floor, the leak cannot be above the floor and should be sought below it. In such a case it is well to start the search in the cellar, examining the end of the service, the meter and its connections and all exposed piping, and, failing to find in any of these a leak sufficient to produce the smell noticed, the points at which the water pipe and sewer enter the cellar, and also any open joints in the masonry of the walls through which gas might be coming in from a leak outside the house. If gas is found to be coming in from outside, steps should be at once taken to have the leak located and stopped. The nearest telephone should be used for communicating with the office if necessary. If no clue is found in the cellar the examination should be continued on the floors above until the leak is found or until all the fixtures and exposed pipes have been gone over. If the leak cannot be located on the premises, investigations should be made of the adjoining properties and the search continued until the leak is found.

When no one leak can be located in the exposed work, its location in the concealed piping can often be closely approximated by smelling at the openings around sliding doors and along the baseboards.

Having located the leak, if it is inside the house, it is well to determine the rate of leakage by means of the test hand on the meter, it having been made certain that no gas is being used at the time. This done, the leak, if it can be gotten at and is such that it cannot be immediately repaired permanently, should be stopped temporarily with soap. If it is around the service, meter or meter connections, the consumer should be told that it has been stopped temporarily, and that the company will have it fixed permanently as soon as possible. This should always be done for a leak in a fixture or in exposed house-piping when the gas company does such work, otherwise the consumer should be told that it is necessary for him to have a gas-fitter attend to it.

If the leak is in the house, and is bad, but cannot be located,

or if located cannot be gotten at, the gas should be shut off at the curb cock, when there is one, or else at the meter. The fact that the gas has been shut off should be at once communicated to the office, using telephone if necessary, so that an official letter can be sent to the consumer explaining why the gas is off and what the consumer must do to get the gas turned on again. If the leak is outside the house and is bad, the cellar windows, and, if necessary, the first floor windows as well, should be opened for ventilation, and the consumer instructed to keep them open and avoid the use of lights until the leak has been found and repaired. When the leak is small the gas need not be shut off in case of inability to locate and repair it, but the consumer should be instructed to get a gas-fitter to attend to it, or told that the company will take further steps to stop it, as the case may be. Such steps would probably include the use of an air pump and ether to locate the leak, and the opening of the floor or wall to afford access to it.

If, on calling to investigate a leak, it is found impossible to gain access to the premises, and there is an odor of gas coming from the keyholes, window joints, etc., the gas should be immediately turned off at the curb cock, if there is one, and, if the house is apparently occupied, the police authorities notified. If unoccupied, access should be gained to the premises by securing the keys from the custodian. In either case, the office should be notified at once by telephone, if necessary.

If a leak is found to be dangerously bad, street help should be secured at once from the office. The occupants of all the premises in which the gas may be finding its way should be notified, and the houses ventilated.

If, when answering a complaint, a careful search reveals no leak, the occupants should be questioned further. Occasionally the statement is made that the odor of gas is noticed at a particular time of day, or a certain condition of the weather. An appointment should be made to call at such a time in order that the consumer may be completely satisfied.

When an escape of gas has caused sickness, or an explosion or fire has occurred, the office should be notified at once, using the telephone if necessary. (Trustees.)

11. What relation, if any, is there between the calorific value of an illuminating gas and its illuminating value when consumed in a standard luminous flame burner?

Ans. There is no definite relation between the calorific value of an illuminating gas and its illuminating value when consumed in a luminous flame burner. The greater part of the calorific value is derived from components which do not of themselves furnish illuminating value, and by reason of change in composition it is possible for an illuminating gas to vary considerably in calorific value and yet be of the same illuminating value or to vary in illuminating power while remaining of practically the same heating value.

In the case of different samples of coal gas made from the same coal, but of different candle-powers by reason of being produced by carbonization of the coal at different temperatures, there is a fairly constant proportion between the illuminating value and the calorific value, as there is also, within certain limits of candle-power, in the case of different samples of carburetted water gas made from the same oil, but this relation does not hold between gases made from different coals or different kinds of oil.

In a lecture delivered before the Institution of Gas Engineers, Prof. V. B. Lewes gave the following table as the average relation between candle-power and calorific value as determined by a number of tests, but said that the results in any particular case might vary 5 per cent. either way from

Candle Power.	Calorific Value B. T. U.s per Cubic Foot.			
	Coal Gas.		Carburetted Water Gas.	
	Gross.	Net.	Gross.	Net.
12	540	480	490	452
13	560	500	510	472
14	585	522	529	489
15	610	542	547	508
16	625	562	567	527
17	647	582	587	547
18	670	603	607	567
19	690	622	627	587
20	712	642	647	607

these, and even with this qualification exception was taken to the figures by some gas engineers. They stand, however, as the most definite statement yet published. (Trustees.)

12. Describe the method of building up the wall of a concrete gas holder tank and the precautions to be observed to insure its being water tight.

Ans. Various methods may be adopted for building a tank wall of concrete. When, as is usual, a trench is excavated around the whole circumference of the tank with an outer diameter greater than that of the outer faces of the piers, it is customary to use wooden forms made to the proper curve, one concave for the outer face and one convex for the inner face of the wall, from 2 feet 6 inches to 3 feet high, and of a convenient length, usually that between two piers. These forms being set on the circumferences of the outer and inner faces of the wall, and properly supported and braced, the concrete is put in place between them and thoroughly tamped. When it has become sufficiently set, the forms are moved to the portion of the wall that is to be next made. For the piers rectangular boxes of the proper size are used in the same manner. A paper read by Mr. C. W. Andrews, before the Ohio Gas Light Association, in 1899 (American Gas Light Journal, Vol. LXX, page 445; Progressive Age, Vol. XVII, page 125), describes very fully the construction of a concrete tank by this method, and should be read by the students.

When the ground is firm and can be securely held by timbering, laid out so that small sections of it can be removed just ahead of the concrete work, as the wall is built up, the outer edge of the excavation can be made vertical and to the proper circle for the outside of the wall at its base, and the concrete tamped between the earth and an inner form. In this way a backing of undisturbed earth is obtained at the bottom of the wall that must of necessity be much more solid than any back filling. When the offset in the wall is reached, an outer form must be used, and the space between wall and earth filled in as usual, but even here the space to be filled is much smaller and the backing that much stronger.

Mr. V. Wyatt, an English constructing gas engineer of great

experience, advocated and used a method for building the walls of large tanks in concrete blocks of the full vertical height of the wall and with radial sides. Each pier formed one block, and each bay between the piers was divided into three. The idea was that, it being cheaper to sink say 48 comparatively small pits than it was to dig and brace a large circular trench, there would be a saving in the cost of the tank. The piers were first put in, the work being carried on on all four quarters of the circle at the same time, then the blocks forming the centres of the bays, and then the two blocks necessary to complete each bay. In each case the excavation was made of just the right shape and size for the wall at the bottom, and timbered in such a way that sections of the timbering three feet high could be removed as the concrete was put in, and the concrete put in in layers three feet deep, filling up the whole space of the excavation at the bottom. When the offset at the back of the wall was reached, a form was used for the back and the concrete tamped between this form and the inner face of the excavation, the space occupied by the form being afterward filled in with earth tightly tamped. All of the sections were made with radial sides and keyed into each other to prevent leakage. Thus the wall, when finished, was a circular arch formed of large blocks. Hoop iron was used, a layer of strips 6″ apart horizontally being placed every 5′ or 6′ vertically, the ends being left projecting and turned up in the piers and centre blocks to be turned down and built in the connecting blocks, thus forming a bond between the blocks. After the wall was finished, the excavation of the centre was carried on without any need of timbering. Mr. Wyatt's paper can be found in the American Gas Light Journal, Vol. L, May 20th, 1889, page 655.

In this case the wall was made water-tight by a lining of 9 inches of brickwork, built so as to leave a space of 2 inches between the outer circumference of the brickwork and the inner circumference of the concrete, this space being grouted with Portland cement as the wall was built.

However, if care is taken to use nothing but sharp, washed sand for the mortar, and for the aggregate, materials free from loam and dirt, and of such size or sizes as to prevent the

existence of any large spaces between the different pieces, and if the mortar and aggregate are in proper proportions and well mixed, and the concrete is put into place carefully and well tamped, the wall will be water-tight without any further treatment.

If these precautions are not taken, then the wall should be rendered with ¼ inch to ½ inch of neat Portland cement, or lined and grouted as above. The lining, while it is more expensive, protects the cement from the action of the water in the tank and the weather, and thus prevents any cracking and possible leakage. Such a lining should, of course, be tied to the concrete wall at proper intervals. (Trustees.)

Third Series of Questions—Section of 1909—Practical Class—American Gas Light Association.

1. To what state of physical subdivision is it advisable to reduce gas coal before charging it into the retorts, in order to secure the best possible results as to yield of gas per pound of coal and per retort? Give the reasons for your answer.

2. Give a description, illustrated by sketches, of a generator furnace, either full depth or half depth, as applied to the heating of coal gas retorts. Pay particular attention to the points at which the primary and secondary air supplies are admitted, and the arrangements for filling the furnace, cleaning the fire and providing the steam required to keep the clinker soft, and do not omit sketches.

3. Give a description, illustrated by a sketch, showing a vertical section of the apparatus, of the construction of a double superheater Lowe carburetted water gas apparatus, and give a brief description of its operation for the manufacture of carburetted water gas.

4. Describe two forms of positive rotary exhausters commonly employed to draw gas from the retorts, or relief holder, and force it through the rest of the apparatus.

5. Using the weights per cubic foot of the various gases given in the answer to Question No. 6 Second Series, and the definition of specific gravity given in the answer to Question No. 5, Second Series, calculate (1) the weight of 1,000 cubic feet of coal gas with a specific gravity of .430; (2) the weight of 1,000 cubic feet of water gas with a specific gravity of .640; (3) the specific gravity of marsh gas (CH_4), and (4) the specific gravity of ethylene(C_2H_4). Give your calculations in each case.

6. In a gas pipe, one end of which is higher than the other, such as the riser pipe in a house or a street main running up hill, and in which there is no flow of gas for the time being, the pressure as shown by a syphon pressure gauge will not be the same at the top and at the bottom. At which point will it be greater? Does the specific gravity of the gas have any influence upon the amount of this difference between the pressures at the two points? Give the reasons for your answers.

7. What are the chief commercial products obtained by the gas manufacturer from the distillation, in retorts, of a ton (2,240 lbs.) of average Pittsburg or Youghiogheny coal; what amount of each is produced and what effect has the temperature of the retorts upon these amounts?

8. What substances are employed to free gas from Ammonia (NH_3) and Sulphuretted Hydrogen (H_2S) respectively, and from Carbon Dioxide (CO_2) and Bisulphide of Carbon (CS_2) in case it is desired to remove the last two impurities?

9. What kinds of joints are commonly employed for connecting together the separate lengths of cast iron gas pipes? What are the respective advantages?

10. When globes are used in connection with flat flame gas burners, what effect does the size of the bottom opening

of the globe have upon the light given out by the burner? How do the various materials of which such globes are usually made act in absorbing the light produced by the burner?

11. What are the different forms of atmospheric burners usually employed for the top burners of gas cooking stoves, and which form do you consider the best for this purpose? Give the reasons for your choice.

12. What are the characteristics of a good building sand?

(Answers to these questions are due September 1st.)

Answers to the Third Series of Questions—Section of 1909—Practical Class—American Gas Light Association.

1. To what state of physical subdivision is it advisable to reduce gas coal before charging it into the retorts, in order to secure the best possible results as to yield of gas per pound of coal and per retort? Give the reasons for your answer.

Answer. The rule generally given for the size of the pieces to which gas coal should be reduced before being charged into the retorts is that the lumps should be broken to the size of a man's fist. But since the size of one man's fist is not necessarily that of another man's fist, it is better to state the rule as being that the lumps should be broken to pieces, none of which measure more than 3 in. along any edge.

The main reason for the attainment of better results when the large lumps of coal are broken to smaller pieces, is that the heat does not readily penetrate to the interior of large lumps and that consequently the gas is never entirely driven off from the coal in the centre of such lumps. Hence, the yield of gas per pound of coal is reduced unless the weight of the charge is kept below the weight that could be properly carbonized if the coal were in small pieces. The same is true of very fine dusty coal, which forms a compact mass in the retort, into the centre of which the heat does not readily

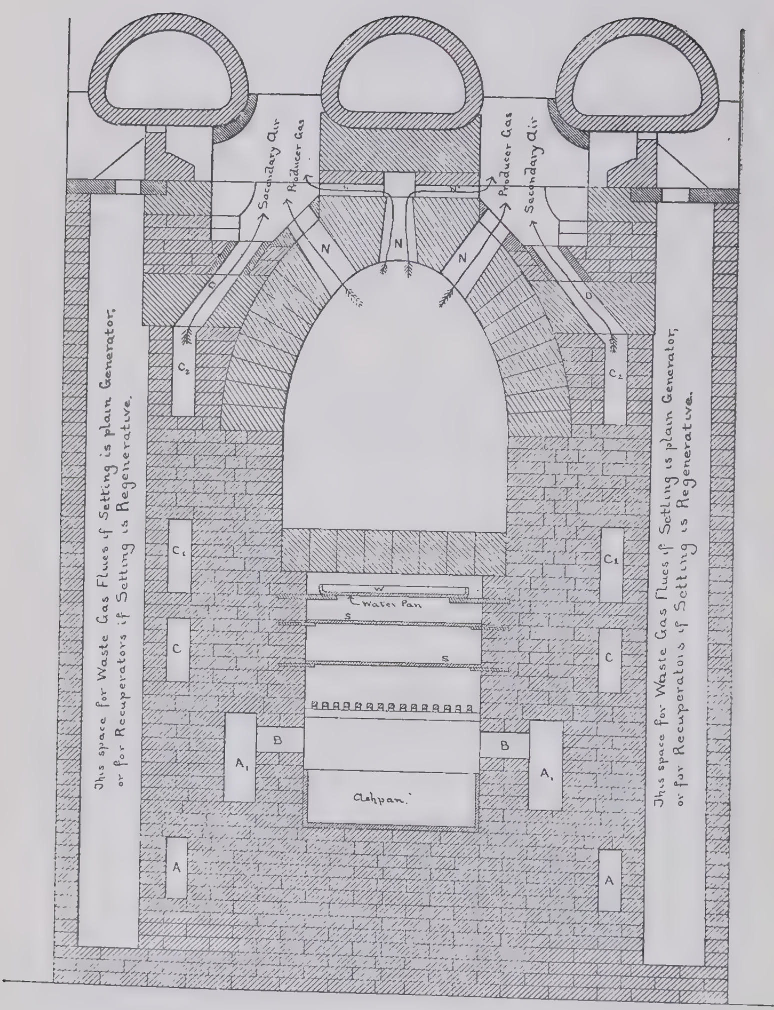
penetrate, and the best results as to yield of gas per pound of coal and per retort per 24 hours can only be obtained from coal in the shape of small lumps not larger than 3 in. cubes.

The small pieces of nearly uniform size possess the further advantage of making it possible to have the weight of the charge uniform throughout the whole length of the retort. This uniformity cannot be secured when large lumps and fine coal are used together, or when only large lumps of irregular shape are used. The custom that obtains in some gas works of charging the top retorts of a bench by throwing into them the lumps that are too large to be handled in the charging scoop should be condemned for these reasons, and care should be taken to have all the lumps reduced to pieces of the size specified above.

According to some experiments, made by a French gas engineer, not only is a larger yield per pound obtained when the coal is in lumps of this size, but the gas is also of slightly better quality than when smaller lumps are used. In making these experiments, lumps of the size being experimented with were used in each case, without any admixture of dust, and the smaller lumps were made by breaking larger ones, so that the coal was exactly the same in every respect except that of size. (Trustees.)

2. Give a description, illustrated by sketches, of a generator furnace, either full depth or half depth, as applied to the heating of coal gas retorts. Pay particular attention to the points at which the primary and secondary air supplies are admitted, and the arrangements for filling the furnace, cleaning the fire and providing the steam required to keep the clinker soft, and do not omit sketches.

Ans. The accompanying cuts show a vertical cross-section and a longitudinal section of a full depth generator furnace, designed to heat a setting of 9 retorts. For a setting of 6 retorts the furnace would be made narrower and would have only one set of gas nostrils through the arch, this set being located along the centre line, but otherwise it would be the same. A half depth furnace would not be as deep as the full depth, but in other respects it would be practically the same.

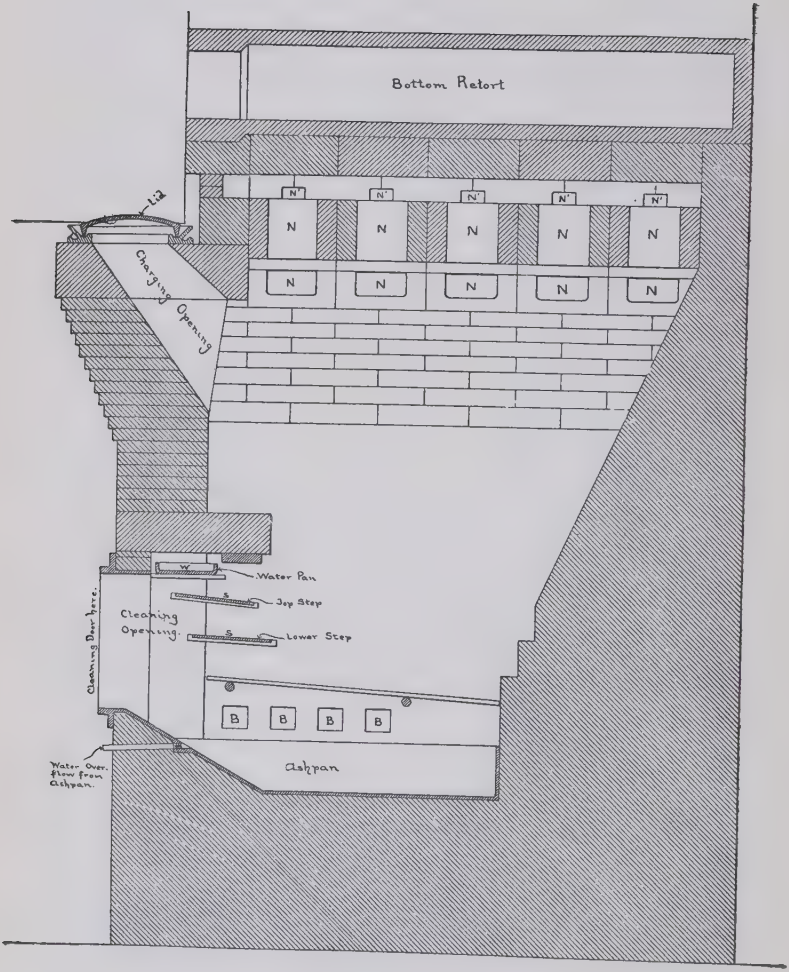


Generator Furnace.

Vertical Cross Section.

This furnace is built directly beneath the setting which it heats. It horizontal section is rectangular, 2 ft. 9 in. wide by 4 ft. 11 in. long at the grate bars, and increasing gradually to 7 ft 5 in. in length at the crown of the arch 7 ft. above the grate bars, while at a height of 2 ft. above the bars an offset of 4½ in. on each side increases the width to 3 ft. 6 in. It is separated from the setting by an arch, the only communication between furnace and setting being through the openings or nostrils, N, N, N, N, in the arch. As shown by the cuts there are in this case 15 of these openings in three rows of 5 each. One row extends along the top of the arch and there is a row on each side a little down from the top. The arch is built of special arch blocks, but the rest of the furnace is built of fire bricks of the ordinary shape and size, those used for the inside lining being especially selected for hardness and ability to withstand the pounding and chipping of the clinkering bars, to which they will be subjected when the fire is cleaned. All the courses of the lining should be set as headers, since the brick, if laid in stretcher courses, will soon be cut through and knocked out of the wall by these bars.

The grate bars are made of wrought iron 1 in. square. Above the ordinary grate at the front of the furnace is what is known as a step grate. It consists of a cast iron water pan, W, placed above two steps formed of cast iron plates, S, S, both water pan and plates being supported by suitable brackets, built into the side walls of the furnace, in such a way that they incline towards the back of the furnace. The upper step projects beyond the inner edge of the water pan, and the lower step projects beyond the inner edge of the upper step. The function of this step grate is to supply, in connection with the ash pan, the steam required to keep the clinker soft, and thus reduce the time and labor needed for cleaning the fire. For this purpose a small stream of water is kept running into the water pan over the inner edge of which it overflows, falling on the top step and running off this to the lower step from which it falls into the ash pan. In this way a thin stream of water is exposed to the heat of the lower part of the fire by which it is evaporated, the steam so formed passing through



Generator Furnace

Longitudinal Section.

the fire and reducing its temperature. The amount of water admitted must be carefully regulated.

Immediately in front of the grate is the cleaning opening, closed tightly by a self-sealing door which is opened only when the fire requires cleaning.

The charging opening, through which the furnace is filled with fuel, is in front at the level of the charging floor for the retorts, the brickwork of the front wall of the furnace being stepped out gradually until it projects enough to permit the opening to be entirely in front of the front wall of the setting, and in such a position that the coke from the middle retorts of a bench of 9s, or the top retorts of a bench of 6s can be drawn directly into the furnace. This charging opening is closed by a loose cast-iron lid fitting into a groove in a cast-iron frame so as to make an air-tight joint with the aid of a little coke dust which is allowed to collect in the groove.

The primary air is drawn in through two flues, A, A, one on each side of the furnace. The fronts of these flues are closed by air ports with slides by which the area of the opening and therefore the amount of primary air can be closely regulated. From these flues the air passes to the recuperators if the setting is regenerative, or direct to the furnace if the setting is not regenerative. In either case it enters the furnace through a number of openings, B, B, B, B, in the side walls directly under the grate bars, the object being to have it distributed as much as possible over the full depth of the grate.

The secondary air is admitted through air ports, similar to those for the primary air, into two flues, C, C, one on each side of the furnace, and passes through the recuperators, when these are provided, or simply through flues running to the back of the setting and forward again. In either case it is taken off from the last longitudinal flue in the series, by short transverse flues, D, D, D, D, each of which opens directly in front of one of the nostrils through which the producer gas passes from the generator to the setting. Each stream of gas is thus supplied with a stream of secondary air for its combustion. There are usually five of these openings on each side of the combustion chamber, as that part of the setting in

which is begun the combustion of the gas is called, spaced equal distances apart from the front to the back of the setting.

To clean the fire, the water is shut off from the step grate, the cleaning door opened, secondary bars driven in above the top plate of the step grate until their points are supported by the sloping back wall of the furnace, the regular bars removed and the ashes allowed to drop into the ash pan, the grate bars replaced, the clinker cut away from the walls and removed, the secondary bars pulled out, dropping the fire on to the grate, the water turned on the step grate, the ashes removed from the ash pan, the primary air openings cleaned out, and the cleaning door closed to stay closed until the fire has to be cleaned again. If the coal contains only a normal amount of ash and the proper amount of water is supplied to the furnace, the cleaning need not be done oftener than once in 48 hours.

All generator furnaces are not built exactly as shown in the cuts, but every such furnace should have a closed top, and the arrangements of primary and secondary air flues and openings and of filling and cleaning doors will be substantially as is here illustrated and described. (Trustees.)

3. Give a description, illustrated by a sketch, showing a vertical section of the apparatus, of the construction of a double superheater Lowe carburetted water gas apparatus, and give a brief description of its operation for the manufacture of carburetted water gas.

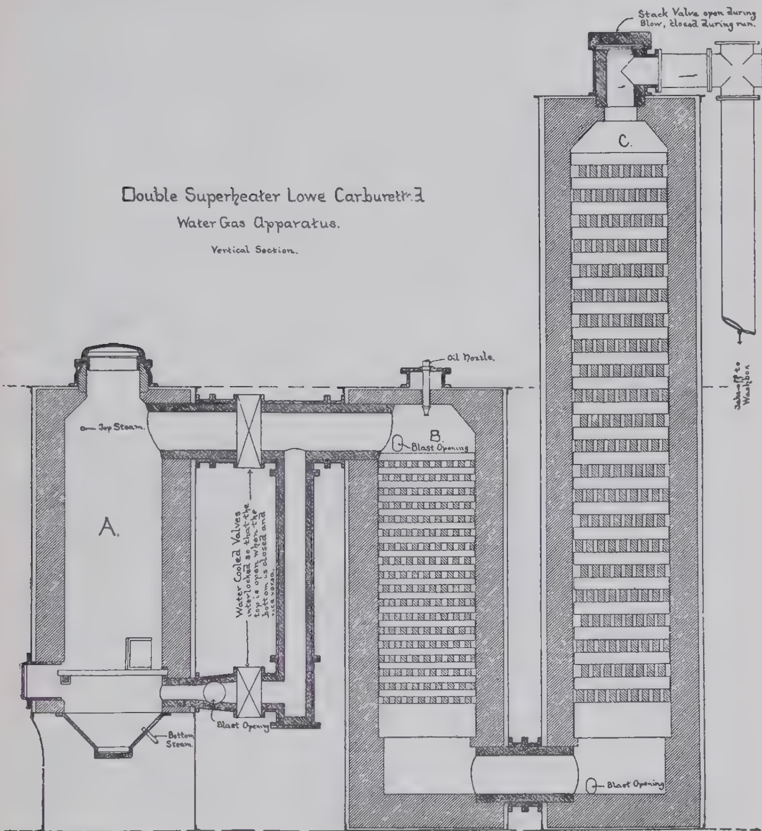
Ans. As is shown on the cut, the double superheater Lowe carburetted water gas apparatus is composed of three cylindrical vessels connected together in sequence. The shells of these vessels are made of wrought iron and they are lined with fire clay blocks. An annular space from 1 in. to 1½ in. wide is left between the lining and the iron shell and is filled with asbestos fibre, or other fire-proof non-conducting material, to diminish the radiation of heat from the shell.

The first vessel, A, is called the generator; the second, B, the carburetter or first superheater, and the third, C, the superheater, main superheater or fixing chamber.

The generator contains the fuel for heating up the apparatus and producing the water gas, and is provided with a grate and cleaning and clinkering doors, at the grate level, and a charging

door or doors on the top. It is usually connected from both the top and bottom to the top of the carburetter.

The carburetter is filled with a checker work of fire brick on edge, set with from 1½ in. to 2 in. clear space between the



rows and so that the rows break joint with each other. It is connected at the bottom to the superheater, or fixing chamber, which is also filled with checker brick. On the top of the superheater is a take-off casting, the top of which opens to the atmosphere and the side to a pipe leading to a small cylindrical vessel, called the wash-box, which contains water in which the open end of the take-off pipe is sealed. The

opening to the atmosphere can be closed by lowering a heavy iron lid called the stack valve, which by its own weight forms a gas-tight joint with the face of the casting. When this lid is lowered, the only outlet from the superheater is through the take-off pipe and the wash-box.

The generator has suitable air blast and steam connections, the carburetter, air blast and oil connections, and the superheater, air blast connections as shown on the cut. The operation of the apparatus is as follows :

A fire is started in the generator, A, and this vessel is filled with coke or anthracite coal which is brought to a high temperature by the air blast. Owing to the depth of the fuel bed and the comparatively limited amount of air admitted to the generator, the combustion of the fuel is not perfect, and the products of combustion passing off through the carburetter to the superheater contain carbon monoxide. By blowing air into the carburetter and superheater this carbon monoxide is consumed in these vessels and the checker work, with which they are filled, is highly heated. The products of the final perfect combustion so obtained pass off through the open stack valve to the stack and the atmosphere. This blowing up is continued until all parts of the apparatus have been brought to the proper temperature. The blast is then shut off and the stack valve closed. Steam is admitted through the steam pipe to either the top or the bottom of the generator, as the case may be, and passing through the fuel bed is decomposed by the hot carbon, its oxygen uniting with the carbon to form carbon monoxide, while the hydrogen is set free. The mixture of hydrogen and carbon monoxide, called water gas, passes over into the carburetter, through the top of which oil is admitted. The oil being vaporized by the heat, the vapors are picked up by the water gas and pass forward with it over the hot checker brick in the carburetter and superheater. The long continued exposure to heat converts the oil vapors into permanent oil gas, this oil gas being mixed during its formation with the water gas, and the result is an illuminating gas, which, properly speaking, should be called carburetted water gas, but is commonly known as water gas. The stack valve being closed, this gas passes out of the superheater by way of

the take-off pipe and wash-box, from which it goes to the scrubber and the rest of the apparatus.

The decomposition of the steam absorbs heat from the fuel in the generator and the distillation of the oil takes up heat from the checker brick in the carburetter and superheater, so that the apparatus gradually cools down during the periods of gas making. When it has been cooled to a temperature at which gas cannot be economically produced, the oil and steam are shut off, the stack valve opened, the blast turned on and the heating up process repeated. The operation thus consists of a series of alternating periods of heating up called "blows," and periods of making gas called "runs." (Trustees.)

4. Describe two forms of positive rotary exhausters, commonly employed to draw gas from the retorts, or relief holder, and force it through the rest of the apparatus.

Ans. The two forms of positive rotary exhausters commonly employed are the Mackenzie exhauster and the Root exhauster.

An elevation and vertical cross-section of the Mackenzie exhauster are shown on the accompanying cut. A is a cast iron case, the general shape of which is cylindrical, with inlet and outlet openings as shown. The moving parts consist of the hollow drum D, open at both ends, the blades B, B, B, and the rolls R, R, R. The length of the drum is such that there is just clearance at each end between it and the inside of the projections of the case (shown on the elevation), the inside diameter of these projections being only a small fraction of an inch larger than that of the drum. This is set with its centre below that of the case, and its circumference tangent at the bottom to the rib E, running along the bottom of the case. It is rotated about its centre by means of a hollow shaft projecting from one end, which shaft is turned by a belt pulley or direct from an engine on the same bed plate as the exhauster. Between the pulley and the drum the shaft is supported by a bearing cast on the case, and a similar shaft projects from the other end of the drum to support it by means of another bearing on that end of the case.

The blades B, B, B, are free to rotate around a fixed shaft, the axis of which coincides with the axis of the main cylinder

of the case, and are of such size that the outer edges just clear the inner circumference of the case on top and the rib E on the bottom, while the ends just clear the inside of the end plates of the case. The shaft around which the blades rotate is bent down at each end, beyond the blades, and passes through the hollow shaft of the drum to an outboard bearing on the pulley end, while at the other end it projects just beyond the outside of the bearing in the case.

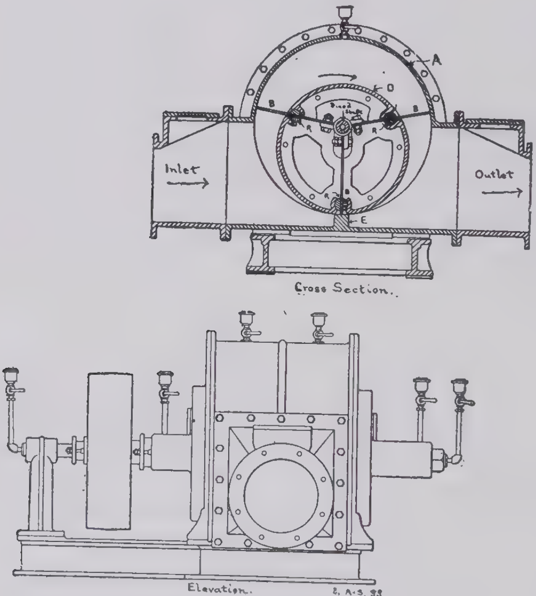


Fig. 1. Mackenzie Exhauster.

As the drum rotates, its circumference, at the points where the blades pass through it, is continually changing its position relatively to the blades, and the function of the rolls, R, R, R, is to permit of a continual sliding motion at these points by rocking back and forth in their bearings in the drum, so as to keep the slots through which the blades pass always in line with the blades.

The action of the exhauster is as follows : The drum, D, being rotated in the direction of the arrow, carries the blades, B, B, B,

with it, and these blades being practically in contact with the circumference and ends of the case, force the gas ahead of them, and thus pass it from inlet to outlet. As the drum is practically in contact with the rib, E, the gas driven forward on top cannot pass back on the bottom, and must go out by the outlet.

By a study of the cross-section it will be seen that in this, as in all similar forms of rotary exhausters, the space on one side is continually increasing in volume, while that on the other is continually decreasing, thus drawing in gas on the one side, the inlet, and forcing it out on the other side, the outlet.

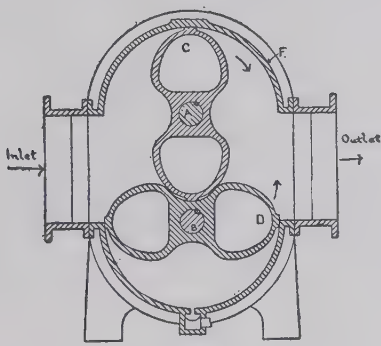


Fig. 2. Cross Section of Root Exhauster.

A vertical cross-section of the Root exhauster is shown on the accompanying cut. F, is a cast-iron case consisting of two half cylinders of equal diameter, separated by a rectangular prism, and with flat ends. The moving parts consist of two impellers, C and D, keyed respectively to the shafts, A and B, and so set in the case that the axes of the corresponding shaft, impeller and half cylinder coincide. The impellers are so shaped that as they rotate each is always in contact, at some point, with the cylindrical portions of the case, and at the same time in contact with the other, while the ends are practically in contact with the ends of the case. The shafts are supported by bearings on the case, and connected with each other at each end by two gear wheels, one on each shaft, of

the same diameter, and with an equal number of teeth, so that the relative positions of the impellers is always the same, at the same point in any revolution. The lower shaft is extended at one end and provided with a belt pulley, or connected direct to an engine on the same bed plate as the exhauster.

The action is as follows: Motion being imparted to shaft B, is transmitted through the gear wheels to shaft A, causing the two impellers to rotate, as shown by the arrows and by the continual increase in volume of the space on the inlet side and decrease in volume of that on the outlet side, to draw the gas from the inlet and force it through the outlet, the contact between the impellers preventing the gas from passing back through the middle. (Trustees.)

5. Using the weights per cubic foot of the various gases given in the answer to Question No. 6, Second Series, and the definition of specific gravity given in the answer to Question No. 5, Second Series, calculate (1) the weight of 1,000 cu. ft. of coal gas with a specific gravity of .430; (2) the weight of 1,000 cu. ft. of water gas with a specific gravity of .640; (3) the specific gravity of marsh gas (CH_4), and (4) the specific gravity of ethylene (C_2H_4). Give your calculations in each case.

Ans. The specific gravity of a gas is defined in the answer to Question No. 5 of the Second Series as the ratio of the weight of any given volume of the gas to the weight of an equal volume of air, the air and gas being measured at the same temperature and pressure. The weight of 1,000 cu. ft. of coal gas with a specific gravity of .430 will therefore be equal to the weight of 1,000 cu. ft. of air multiplied by .430. As the weight of 1 cu. ft. of air at 60° F. and 30 in. pressure is given in the answer to Question No. 6 of the Second Series as .076357 lbs., 1,000 cu. ft. will weigh 76.357 lbs. Hence, $76.357 \times .430 = 32.83$ lbs. is the weight of 1,000 cu. ft. of coal gas with a specific gravity of .430.

In the same way the weight of 1,000 cu. ft. of water gas with a specific gravity of .640 is equal to $76.357 \times .640 = 48.87$ lbs.

The specific gravity of marsh gas according to the definition

will be equal to the quotient obtained by dividing the weight of a cubic foot of marsh gas by that of a cubic foot of air. The weight of marsh gas is given as .042308, therefore the specific gravity of marsh gas equals $\frac{.042308}{.076357} = .55408$. In the same way the specific gravity of ethylene is equal to $\frac{.074039}{.076357} =$ .96964. (Trustees.)

6. In a gas pipe, one end of which is higher than the other, such as the riser pipe in a house or a street main running up hill, and in which there is no flow of gas for the time being, the pressure as shown by a syphon pressure gauge will not be the same at the top and at the bottom. At which point will it be the greater? Does the specific gravity of the gas have any influence upon the amount of this difference between the pressure at the two points? Give the reasons for your answers.

Ans. A syphon gauge will show a greater pressure at the high end of a pipe filled with illuminating gas through which there is at the time no flow of gas, than it will show at the low end. The amount of the difference between the pressure at the high end and that at the low end is influenced by the specific gravity of the gas and increases as the specific gravity decreases.

The existence of this difference in gauge pressure between the top and the bottom of an inclined pipe and the dependence of its amount upon the specific gravity of the gas are due to the facts that the syphon gauge does not show actual pressures, but only the difference between the actual pressures exerted on each leg of the gauge, and that the actual pressure of both the outside air and of gas at rest in a pipe decreases in proportion to their weight as the distance of the point of observation from the centre of the earth increases. The actual pressure of both air and gas will be less at the top of the pipe than at the bottom by an amount equal to the weight of a column of air or gas of unit area and of a height equal to the difference in elevation between the two ends of the pipe. As the specific gravity of illuminating gas is less than one, that is, such gas is lighter than air, the weight of the column of gas will be less than that of the column of air. Therefore,

the actual pressure of the gas will decrease less than the actual pressure of the air, and consequently the difference between the actual pressure of the gas and that of the air will increase with an increase in elevation. The lighter the gas, that is, the lower its specific gravity, the smaller will be the decrease in its absolute pressure and the greater the increase in the gauge pressure for any given increase in elevation.

The amount of this increase can be obtained for any particular case by dividing the difference between the weight of a column of air with an area of one square inch and a height equal to the difference in elevation between the two ends of the pipe and that of a column of gas of the same area and height by the weight of a cubic inch of water. For a gas with a specific gravity of .700 and for a difference of elevation of 100 ft. between the two ends of the pipe, the calculation would be as follows:

The height of the columns of air and gas will be 100 ft. or 1,200 in., and as the area of the columns is one square inch, the volume will be 1,200 cubic inches. A cubic foot of air weighs .076357 lb., and a cubic inch weighs $\frac{.076357}{1728} = .00004419$. 1,200 cubic inches of air, then, weigh $.00004419 \times 1,200 = .053028$ lb. Since the specific gravity of the gas is .700, the column of gas will weigh $\frac{7}{10}$ as much as the column of air, and the difference between the weight of the column of air and that of the column of gas will be equal to $\frac{3}{10}$ the weight of the column of air, or to $.053028 \times .3 = .0159084$. The weight of a cubic inch of water is .036 lb. and the increase in pressure will therefore be $\frac{.0159084}{.036} = .44$ in. Thus, a gas with a specific gravity of .700 will show an increase in pressure of .044 in. for each 10 feet increase in elevation, or an increase in pressure of $\frac{1}{10}$ in. for each 22.7 ft. of rise.

In the same way we find that a gas with a specific gravity of .600 will show an increase in pressure of .059 in. for each 10 ft. of rise, or an increase of $\frac{1}{10}$ in. pressure for each 16.9 ft. of rise; gas with a specific gravity of .500 will show an increase of .074 in. for each 10 ft. of rise, or an increase of $\frac{1}{10}$ in. for each 13.5 ft. of rise; gas with a specific gravity of .400 will show an increase of .088 in. for each 10 ft. of rise, or $\frac{1}{10}$ in. for each 11.4 ft. of rise, and gas with a specific gravity of .300

will show an increase of .103 in. for each 10 ft. of rise, or an increase of $\frac{1}{10}$ in. for each 9.7 ft. of rise. (Trustees.)

7. What are the chief commercial products obtained by the gas manufacturer from the distillation, in retorts, of a gross ton (2240 lbs) of average Pittsburg or Youghiogheny coal? What amount of each is produced, and what effect has the temperature of the retorts upon these amounts?

Ans. The chief commercial products obtained by the gas manufacturer from a gross ton (2240 lbs.) of average Pittsburg or Youghiogheny coal distilled in coal gas retorts at a fairly high temperature are:

11,000 cu. ft. of gas of 14 to 15 candle-power as determined with a flat flame burner,
1,450 lbs. of coke,
14 gals. of tar,
30 gals. of ammoniacal liquor of from 8 oz. to 10 oz. (4° to 5° Twaddell) strength,
1 lb. of retort carbon.

These are average figures, but no two works will agree exactly in the results obtained. The 1,450 lbs. of coke would be the total amount of coke produced and would contain about 1,250 to 1,300 lbs. of clean coke, and 200 to 150 lbs. of dust or breeze. The amount of breeze will vary with the manner in which the coke is handled, but should not run above the highest figure given. The amount of carbon specified is that removed from the retorts after scurfing and left for sale, and not the total amount actually deposited in the retorts.

Variations in the temperature of the retorts affect principally the yield of gas and tar, and, to a slight extent, the quantity of ammonia produced. The higher the temperature the greater the amount of gas, and the smaller the amount of tar that is produced. At low heats the make of gas will not be over 10,000 cu. ft. per ton, and there will be an increase in the amount of tar produced. The weight of coke is not much affected by the temperature of carbonization, though it will be slightly greater with low heats, owing to the retention of a small amount of volatile matter that would be driven out by

high heats. The effect of the temperature of the retort on the production of ammonia has not been as thoroughly determined as the effect on the yield of gas and tar, but a good authority (Mr. L. T. Wright) states that the production of ammonia is greater with medium heats than it is with either high or low heats. The production of carbon increases as the temperature of the retort rises. (Trustees.)

8. What substances are employed to free gas from Ammonia (NH_3) and Sulphuretted Hydrogen (H_2S) respectively, and from Carbon Dioxide (CO_2) and Bisulphide of Carbon (CS_2) in case it is desired to remove the last two impurities?

Ans. Water is the substance employed during the manufacture of gas to free it from Ammonia (NH_3) for which water has, when cold, a great affinity. The quantity of Ammonia that can be absorbed by any given quantity of water decreases rapidly as the temperature rises, and therefore the complete removal of this impurity can not be effected until the gas has been cooled down to a temperature of 60° F. or less.

Hydrated Sesqui-oxide of Iron, or ferric oxide, is the substance commonly employed for the removal of Sulphuretted Hydrogen (H_2S) from gas. Its composition, when freshly made, is expressed by the formula $Fe_2O_3 . 3H_2O$, but under the conditions to which it is exposed in practice it loses water, and its actual composition, as employed in gas works, is probably that expressed by the formula $Fe_2O_3 . H_2O$.

Hydrate of Lime, or slaked lime [$Ca(OH)_2$], is also sometimes employed for the removal of H_2S from gas, but in most cases it is much more expensive than ferric oxide, and its use should be confined to the removal of Carbon Dioxide (CO_2) when it is considered desirable to remove this impurity.

The active agent employed for the removal from gas of Bisulphide of Carbon (CS_2), when a special effort is made to remove this impurity, is the sulphided lime obtained by passing through slaked lime gas containing sulphuretted hydrogen, but no carbon dioxide and no oxygen. The exact composition of the compound of lime and sulphur formed by thus fouling slaked lime is not known, but it is supposed to be either

calcium or hydrosulphide [Ca $(SH)_2$] or calcium hydroxyhydrosulphide (Ca OH.SH). In practice the slaked lime is sulphided after it has been placed in the purifying box, by passing through it the usual way, and preferably while it is still warm, gas freed from carbon dioxide and oxygen, but containing sulphuretted hydrogen. When the lime is sulphided the valves are so set that the gas enters the box after having been freed from carbon dioxide and sulphuretted hydrogen. In this country it is not usual to make any especial effort to remove bisulphide of carbon from illuminating gas, since carburetted water gas and coal gas made from the majority of the gas coals do not contain any excessive amount of this impurity, and both lime used in the ordinary way and the free sulphur contained in oxide of iron that has been fouled and revivified several times will absorb enough of it to bring the amount left in the gas below the point where its presence would be noticed when the gas is burned. (Trustees.)

9. What kinds of joints are commonly employed for connecting the separate lengths of cast-iron gas pipes? What are their respective advantages?

Ans. The joints commonly employed in this country for connecting together the separate lengths of cas-iron pipes are the lead joint and the cement joint.

The lead joint, while as a rule more expensive than the cement joint, has the advantages of being more easily cut out, more easily repaired, and of allowing the pipes to expand and contract, under the influence of changes of temperature, without fracture, since the lengths can move in the joints.

On the other hand, the cement joint is cheaper and more rigid than the lead joint, and when properly made will remain tight under almost any possible conditions. A line of pipe laid with cement joints if exposed to changes of temperature will not show small leaks at the joints as will one laid with lead joints, but, on the other hand, it will probably be fractured in one or more places.

In most instances the choice between lead and cement joints is determined by the relative disadvantages of a number of small leaks, no one of which is large enough to be dangerous,

and one large leak, which latter will be more quickly detected, but, because of allowing more gas to leak in a given time, is more liable to cause damage. In one large city, lead joints are used in the heart of the city, where gas from a leak might collect in closed spaces, and cement joints are used in the outskirts, where the conditions are more favorable for the gas from a leak passing away into the open air without forming an explosive mixture in a confined space. A frequent practice is to lay the pipes with cement joints, except that at intervals of from six to twelve lengths a lead joint is put in to act as an expansion joint—the location being marked and noted, and and the lead joint occasionally examined. This should make pipe with cement joints practically as free from liability to fracture as pipe with lead joints. (Trustees.)

10. When globes are used in connection with flat flame gas burners, what effect does the size of the bottom opening of the globe have upon the light given out by the burner? How do the various materials of which such globes are usually made, act in absorbing the light produced by the burner?

Ans. If the bottom opening of a globe used with a flat flame burner is made too small, the access of air to the flame is unduly restricted and the combustion of the gas tends to become imperfect. At the same time the air entering through the bottom of the globe acquires a high velocity in passing through the small opening and causes the flame to flicker, in some cases even to smoke, just as would an open flame exposed to the wind. For these reasons a flat flame burner surrounded by a globe with a small bottom opening will not originally yield as much light as will the same flame burning in the open air in a space free from draughts. To avoid this detrimental effect no globe having a bottom opening less than 4 in. in diameter should be used over a flat flame burner.

In King's Treatise (Vol. III, page 35) the following table is given as showing the effect of shades made of the materials named in absorbing light when placed over a gas burner.

	LOSS OF LIGHT Per Cent
Clear glass	10.57
Ground glass (entire surface ground)	29.48
Smooth opal	52.83
Ground opal	55.85

These figures are the results of experiments made in 1860 by Mr. W. King of Liverpool. It is to be presumed that the "shades" tested were the same as globes and that the tests were made with the light in the same horizontal plane as the photometer disc. It is not stated whether the burner used was an argand or a flat flame.

Mr. F. W. Hartley also investigated this subject of the absorption of light by globes about 1880, and gave the results of this investigation in a series of papers published in the Journal of Gas Lighting, etc. (Vol. XXXVII, pp. 54, 94, 134). He determined the effect of globes upon the available light from both argand and flat flame burners and for both horizontal lighting, that is, with the photometer disc on a level with the flame, and for overhead lighting, that is, with the flame above and to one side of the photometer disc, flat flame burners enclosed by globes being usually used mainly for the illumination of objects lying in horizontal planes below that of the lights themselves. From the results of his experiments he drew the following conclusions for horizontal lighting:

"That a clear glass globe increases the sensible light from a flat flame.

"That globes of ground glass obstruct less light than sheets of ground glass. That the percentage loss diminishes as the light grows stronger and is for an average light 18 to 20%.

"That opal globes obstruct an amount of light equal to from 33 to 65%."

The increase of sensible or available light found with a clear glass globe results from the fact that the amount of light absorbed by the glass in front of the flame is more than compensated for by the extra illuminating value of the flame due to the increased steadiness secured by the use of a properly designed globe and by the light reflected from the portion of the globe behind the flame. This reflection also explains the

fact that globes obstruct less light than sheets of the same material.

For overhead lighting with the light 2 ft. 3 in. above the photometer disc and distant from it 2 ft. along the horizontal line, that is, with the disc on a line passing through the light at an angle of 41°–38′ with the vertical, he found "that glass globes with flat flame burners increased the power of the light—clear globes about 6%; ground glass about 9%; albatrine (a species of opal) about 23% and German opal about 21%."

These figures, of course, only hold for the particular angle mentioned. At this angle the direct rays falling on the disc passed through the bottom opening of the globe, and were, therefore, not subject to any absorption of light by the glass, and these direct rays were reinforced by light reflected from the upper portion of the globe. Had the angle taken been such as to cause the rays of light falling on the photometer disc to pass through the globe, the absorption of light would probably have been approximately the same as that shown in the horizontal lighting experiments.

The above refers to the ordinary globes with smooth surfaces and not to globes such as the holophane, which are especially designed to increase the amount of light given out at certain angles. (Trustees.)

11. What are the different forms of atmospheric burners usually employed for the top burners of gas cooking stoves, and which form do you consider the best for this purpose? Give the reasons for your choice.

Ans. The different forms of atmospheric burners commonly employed for the top burners of gas cooking stoves may be classed as ring burners with drilled holes, radial or star burners with drilled holes, ring burners with slits sawed in them, and star burners with sawed slits. Annular slit ring burners and serrated disc, or cap burners, are also sometimes employed, but the drilled or sawed burners are the only ones used on the better class of stoves.

One series of careful experiments seems to show that given equally good design in other directions, as for instance in the form and size of the air mixers, the drilled ring burners

possess the greatest efficiency, that is, enable the largest proportion of the total heat given by the gas consumed to be utilized in useful work. Next to the drilled ring burner comes the drilled radial burner, followed by the sawed ring and the sawed radial burners in the order named.

In the answer of one of the members of the class, who has made a number of tests of gas stove burners, ring and star burners are compared as follows:

"There are two general shapes of burners, the ring and the star. The efficiency of the one as compared to the other will run about the same, but the star burner offers the advantage over the ring in that it is possible to drill more ports on its surface and so a higher rate may be burned on it with good combustion.

"By this is meant that, taking a star burner and a ring burner, both of which are set 1¼ in. from the bottom of the vessel and burning 10 cubic feet per hour, it will be found that the efficiency will be about the same but if the consumption is increased to 13 cubic feet per hour, it will be noted that the efficiency of the star burner will only drop about 2% while the ring burner would not do at all because of the poor combustion. To drop the burner to get proper combustion means to drop the efficiency.

"In this point lies the advantage of star over ring burners, with the one exception of a ring burner in which there is a double row of ports and a ventilated space between the two rows.

"I prefer a cored cast star burner, 4¼ in. diameter, eight arms and forty-eight No. 40 gauge ports spaced $\frac{5}{16}$ in. apart from centre to centre and with the ports around the centre air well drilled at an angle of about 60°, the flame pointing in toward the centre of the burner.

"This burner will give as high an efficiency as any other burner and will permit of a maximum rate per hour with good combustion and proper efficiency."

It is, however, undoubtedly true that the average ring burner gives a better efficiency than the average star burner, because in the former there is a better supply of air to all parts of the flame, owing to the fact that the air is free to rise on

the inside as well as the outside of the ring, while in the star burner, unless very well designed, the access of air to the gas issuing from the central portions of the burner is very much obstructed. The greater efficiency of the burners with drilled holes, as compared with those having the orifices in the form of slits, is probably due in part to the greater opportunity for free access of air to all parts of the several jets of flame that is given by the drilled form, and partly to the smaller ratio of perimeter to area of circular as compared with rectangular orifices, which affords a smaller contact between flame and burner and consequently a smaller abstraction of heat from the flame by the burner. It is an observed fact that in other forms of non-luminous burners the circular aperture gives much the best results, and this rule seems to apply as well to the atmospheric burners used for gas stoves. (Trustees.)

12. What are the characteristics of a good building sand?

Ans. "Sand is mixed with lime or cement to reduce the cost of the mortar, and is added to lime also to prevent the cracking which would occur if lime were used alone. Any material may be used to dilute the mortar, provided it has no effect upon the durability of the cementing material, and is not itself liable to decay. Burnt clay, powdered brick, slag or coal cinders may be used. Of course, the strength of the mortar decreases with the amount of dilution.

"It is usually specified that sand for mortar should be clean and sharp, and free from pebbles.

"Although it is customary to require that only clean sand shall be used in mixing mortar, a small amount of finely powdered, inert diluting material, as clay, for example, will not materially decrease the strength of the mortar. Clay, when dissolved or finely pulverized, consists of an almost impalpable powder, and, when mixed with the sand, its particles occupy the interstices between the particles of cement and sand, and are also completely enveloped by the cementing paste.

"The cleanness of sand may be tested by rubbing a little of the dry sand in the palm of the hand, and after throwing it out noticing the amount of dust left on the hand. The clean-

ness of sand may also be judged by pressing it together between the fingers while it is damp; if the sand is clean, it will not stick together, but immediately fall apart when the pressure is removed. As a rule, reasonably clean sand can be had without any extra trouble or expense.

"Sharp sand, that is, sand with angular grains, is much better than that with rounded grains, although it is often difficult to obtain. The sharpness of sand can be determined approximately by rubbing a few grains in the hand, or by crushing it near the ear and noting if a grating sound is produced; but an examination through a small lens is better. The requirement that 'the sand shall be sharp' is practically a dead letter in most specifications.

"Sand should be screened to remove the pebbles, the fineness of the screen depending upon the kind of work in which the mortar is to be used. Every particle of the sand of 'aggregate' should be completely covered with the cement or 'matrix,' and since, when the grains in a given volume are small, the magnitude of the total surface to be covered is greater than when the grains are large, it follows that fine sand requires a larger proportion of cement than coarse sand. Any specification or plan contemplating the use of coarse sand must therefore be altered, if fine sand alone is used, else the quality of the mortar will be impaired. The best sand is that in which the grains are of different sizes. The more uneven the sizes, the smaller the voids, and hence less cement is required. The voids of ordinary sand average from 0.3 to 0.5 of the volume." (Baker.)

First Day—Afternoon Session.

Convention called to order at 2:15 P. M., President B. W. Perkins in the chair.

The President: Is Mr. Dickey ready to report for the Committee on Meters? We will listen to the report of the Committee on Uniformity of Gas Meters. Mr. Dickey, I think, is not in the room, but the report will be read by Mr. Dunbar.

REPORT OF COMMITTEE ON METERS.

Your Committee recommends that the Association should adopt as a standard differential pressure at which to measure the capacity of meters, that of 3/10 of an inch water column pressure, the manufacturer to arrange to supply the gas company with five (5) standard sizes of meters, which should have a capacity to measure gas at the previously mentioned differential pressure, respectively, at the following rates per hour:

100 cubic feet.
150 cubic feet.
300 cubic feet.
500 cubic feet.
750 cubic feet.

For the convenient testing of the capacity of meters, air may be used, proper corrections being made for the specific gravity of the measuring medium. The Committee recognizes the fact that different gases have different specific gravities, and recommends that the hourly capacities as above noted should be considered correct with a gas having a specific gravity of .55.

We would also recommend that meters be designated by their cubic foot hourly capacity at the standard differential 3/10 of an inch water column pressure, and standard specific gravity of .55 for gas, and should be badged to show the hourly capacity in cubic feet.

We recommend that no larger sizes be specified until further data is available from the attempts to manufacture meters which are rational in dimensions in all their parts.

CHARLES H. DICKEY, *Chairman.*
PAUL DOTY.
H. C. ABELL.

THE PRESIDENT: Gentlemen, what is to be done with this report?

MR. WM. MCDONALD: I move the adoption of the report.
Motion seconded.

A Member: Mr. Chairman, I would amend that by moving that the report be received and filed.

The President: I think that would go without saying as the effect of the motion to adopt the report.

Mr. A. S. Miller: Mr. President, may I ask what the adoption of this report will carry with it? Would it mean that the members agree to ask the meter manufacturers to change their system, or is it just a suggestion to the meter manufacturers that they change their system?

The President: I may state, Mr. Miller, that I think that this is more of a suggestion to the manufacturers as a way to arrive at uniformity.

Mr. Horton: Mr. President, this is rather of an important matter. Could we not have the consideration of it postponed, and have a little time to think it over before we commit the Institute to a standard of this kind?

The President: That is for this body to determine.

Mr. Wm. McDonald: Mr. President, if there is any member of the Committee here I think that they should elucidate that a little before we adopt it. It is an important matter. At the same time, the subject was pretty well threshed over last year. It was talked over pretty thoroughly, and, as I understand it, this report is made in accordance with the suggestion which was made last year.

The President: I do not think that any of that committee are here.

Mr. Wm. McDonald: Then, Mr. President, I would like to withdraw my motion to adopt the report. I think the whole association ought to have an opportunity to see it. I think it should be more fully discussed before we adopt it.

Mr. A. S. Miller: I would move, Mr. President, that the report be printed and sent to the members of the Institute, and then that it be made an order of business for the next meeting.

Motion seconded.

THE PRESIDENT: Gentlemen, it has been moved and seconded that this report be printed, that a copy be sent to each member, and that it be considered at a future meeting. Are there any remarks on that motion? All in favor of the motion will say "Aye." Contrary minds, "No." The motion is carried.

Now we will listen to Mr. Rusby's paper on

CONSUMERS' METERS—CAUSES OF VARIATION IN PROOF.

In the following is presented some information concerning the causing of erroneous registration and proof of dry gas meters through decay and "bleaching" or hardening of leather diaphragms and other actions. Although the topics discussed are few in number, it is believed that they cover some serious causes of meter registration troubles. This information has been derived from working experience, and also from rather extensive special investigation and experiment by the Company with which the writer is connected. The information will be briefly presented under various proper headings.

DIAPHRAGM DECAY.

Where diaphragms are of such size or so mounted that they continuously or frequently in their motion come in contact with any portion of the metal of the case, injury is almost certain to follow. In our experience, a great number of meters which have become "non-register" or seriously slow, have revealed upon examination diaphragms ruined through this cause. The coating of tin is found to be removed from the sheet iron of the case at the point of contact, and corrosion is in progress. In many cases, the particles of iron compound will be found to have impregnated the leather to very visible extent. The leather is found to be entirely rotten at this point, the particles of iron probably having contributed to this effect; in a great number of cases the leather remote from these points of contact will be found thoroughly sound, and still capable of years of wear. Furthermore, an examination of the meter case metal at the point of contact reveals that the

product of the corrosion of the iron stands out from the surface in small and sharp projections, which quickly rasp the leather entirely through. The precise cause of this action between the metal and leather we are unable to state. In either purchasing meters, or equipping them with new diaphragms, we, therefore, now have the latter of such size and so attached that this contact with the meter case is entirely avoided. It is already the common custom of makers, we believe, to insert a leather ring between the diaphragm letter and the metal rings to which they are attached. Attention was called to this danger from metal and leather contact by Mr. B. H. Spangenberg in a paper read at the 1904 meeting of the A. G. L. Association, but is thought worthy of second mention here.

Meter diaphragms were formerly, and, indeed, may to some extent still be, attached to their rings by means of wire winding. It has been our experience that wire for this purpose is inferior to cord. An action probably somewhat similar to the above appears to take place between the wire and the leather, and many cases of the breakage of the diaphragm at this point have resulted.

As to the deteriorating effect upon the leather of the various sulphur compounds and other impurities of gas, it seems certain that almost any one of them will have such serious effect if existing in considerable percentage. Ammonia is one of the worst ; diaphragm leather dipped into ammonia solution is very quickly reduced to a gluey condition, and on subsequent drying is as brittle as paper ; the same general tendency exists with gaseous ammonia. The small quantities of these constituents existing in a properly purified gas have, however, a very slow action indeed, as is shown by the long life of properly mounted diaphragms passing a good quality gas.

We can find little literature upon this subject. There has been some discussion of it by German gas engineers (see London Journal of Gas Lighting, Sept. 27, '04, and Gas World, Sept. 10 and Oct. 8, '04), and as the result of their experiment and observation the following statements, among others, are made. Of the gas vapors, xylene is far the most powerful solvent for diaphragm oils, removing even the

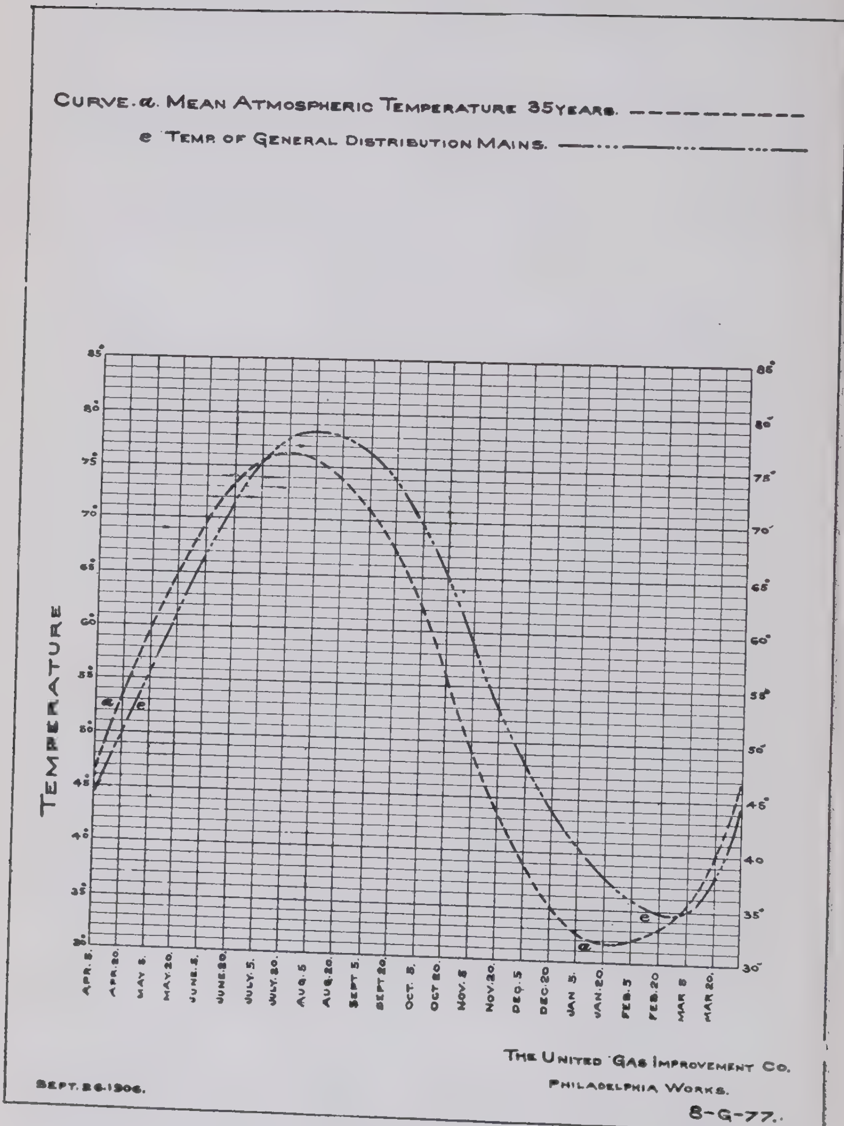

CURVE. a. MEAN ATMOSPHERIC TEMPERATURE 35 YEARS.
e TEMP. OF GENERAL DISTRIBUTION MAINS.
TEMPERATURE
85° 80° 75° 70° 65° 60° 55° 50° 45° 40° 35° 30°
APR. 5. APR. 20. MAY 5. MAY. 20. JUNE. 5. JUNE. 20. JULY. 5. JULY. 20. AUG. 5 AUG. 20. SEPT 5. SEPT 20. OCT. 5. OCT 20. NOV. 5 NOV. 20. DEC. 5 DEC. 20 JAN. 5. JAN. 20. FEB. 5 FEB. 20 MAR. 5 MAR. 20.
THE UNITED GAS IMPROVEMENT CO.
PHILADELPHIA WORKS.
SEPT. 26. 1906.
8-G-77.

Fig. No. 1.

refractory oxidized oil compounds used on textile diaphragms. Among the gas vapors are liable to be some which, after deposition in a meter, become rancid or acidify through chemical change. Also "heavy hydrocarbons" gradually deposits a non-volatile sticky compound on meter diaphragms, valves, etc. These papers and discussions concern themselves chiefly with the destruction of textile diaphragms which were largely in use, and had given much trouble by perforation, breakage, etc.; there is some discussion of leather diaphragms, however, which are pronounced superior to the textile ones.

It seems reasonable to suppose that a leather diaphragm if kept continually saturated with diaphragm oil, should deteriorate very slowly indeed from the action of these impurities, etc. Our experiments upon the action of ammonia on leather show a marked retardation of injury when the leather is thus thoroughly oil saturated.

Bleaching or Drying of Diaphragms.

In a paper presented by Mr. W. H. Gartley at this meeting are given the facts concerning condensation of vapors from illuminating gas with falling temperatures, and also chart showing the average yearly temperatures of the atmosphere and of the general distribution gas mains at Philadelphia. For the convenience of the reader, these temperature curves are here reproduced. (See Figure No. 1)

From these curves it will be seen that from the middle of July to about the first of March, the average atmospheric temperature is below that of the mains, and consequently house meters which are so located as to experience about the atmospheric temperature will generally condense vapors from the gas which they receive from the street, provided that the gas is saturated with vapors at this street main temperature; this last condition will exist unless the gas has been subjected to very low temperature at the works before its discharge into the mains, or has passed through some exposed part of the mains, furthermore we have taken the trouble to place, and for the period of a full year very frequently read, maximum and minimum recording thermometers immediately adjoining

meters in a large number of buildings, these buildings so chosen that they represented about average conditions. We find that the average of all these minimum temperatures is higher than the temperature of the street mains during only the months of December, January, February, March, during which months buildings are experiencing their maximum heating, and, on the other hand, the temperature of the street mains is the lowest during every one of the remaining months of the year. The average meter appears to experience more or less frequent fall of temperature below that of the street mains, this condition existing to greatest extent during the fall months, as shown by the above temperature curves. On the other hand, the maximum temperatures are, especially during the winter months, far above those of street mains, producing a "super-heated" or drying condition of the gas at the meter, and in the case of many meters, set in warm places, this condition will be long, continued and severe.

During the spring, summer and fall months, therefore, there is a general tendency toward the frequent precipitation of vapors in the meters. It is worthy of note also that because of an affinity between the diaphragm oil and the vapors of the gas, absorption of the latter will occur to considerable extent even if the temperature of the meter be somewhat above that of the street mains; our experiments have shown this fact, and it has indeed been noted by other observers. These absorbed and condensed vapors are powerful solvents for the oil with which the diaphragms are saturated, when placed in the meter. In meters which experience to marked extent this absorption and condensation the diaphragm oil is, therefore, quickly thinned by the precipitated vapors and drained out of the leather, leaving the diaphragm saturated with merely the volatile condensed vapors from the gas. If, now, the temperature of the meter be from any cause raised so that the gas which it is passing becomes "superheated" there is a rapid evaporation of these condensed vapors, and the diaphragm is soon left dry or bleached, and somewhat porous, stiff and shrunken. Its registration is thereby affected, as will be shown in the following, and moreover, while thus deprived of the protection of its diaphragm oil the leather is

probably subject to injurious action by water vapor and the minute quantities of the various impurities and oxygen in the gas. The diaphragm oil, once thus removed from the diaphragms and distributed over the bottom of the meter, will not thereafter be again absorbed by the leather, especially if the leather (as should be the case) stands clear of the bottom of the meter. During the remaining period of its service, therefore, the leather will be unprotected by any diaphragm oil; it may again become wet from deposited vapors, but will immediately dry on any subsequent rise of temperature, and the registration of the meter will, therefore, vary, as will be shown in the following, according to its condition of dryness or dampness.

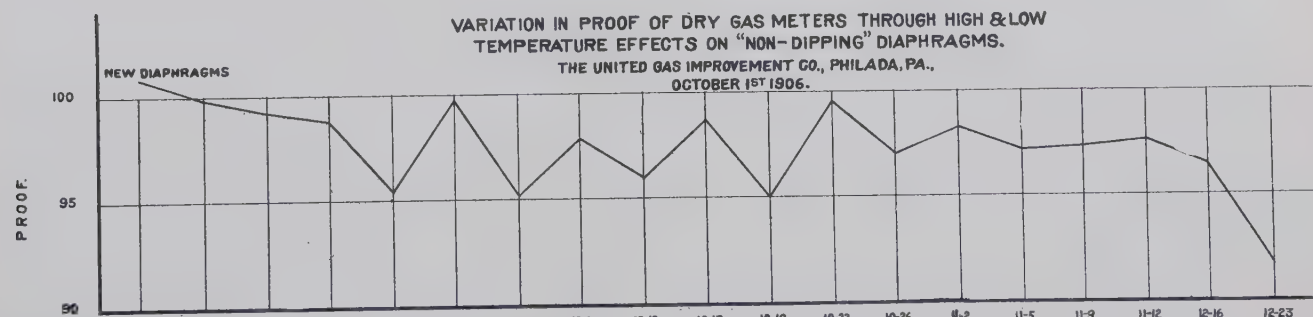
Much annoyance having been experienced from this bleaching of diaphragms, and the foregoing general explanation being arrived at, we have made very considerable special experiment to ascertain the exact facts concerning its effect upon registration, and have also expended very considerable time and money in endeavoring to find a means of maintaining the diaphragm in a constant condition under the continually varying conditions of vapor deposition and drying, above mentioned.

Our special experiments upon the bleaching diaphragms and consequent effect upon meter registration, alluded to in the preceding paragraph, were made as follows: A large number of boxes containing water were prepared in which the meters could be set. The water in these boxes was artificially cooled, and the gas passing through the meters was thereby brought to any desired temperature. Before admission to these meters the gas supply was cooled and scrubbed in external vessels to known temperatures relatively to the street mains, so that its condition of vapor saturation was accurately known. Gas was then passed through the meters in large quantity and for considerable periods, the temperature of the meter being successively lower and higher than the temperature of the gas at its entrance into the meter, with consequent first condensation of vapors in the meter and washing off of the diaphragm oils, and a succeeding evaporation of the condensed vapors, producing a drying or bleaching of the diaphragm.

The meter was removed, drained and proven at the conclusion of each low temperature period and each high temperature period. The following curve, which represents the average record of one lot of three meters, is generally typical of the provings of such meters. (See Figure No. 2.)

The + and — temperature figures indicate that the meters were proven immediately after passing a quantity of gas this number of degrees above or below the temperature of the gas entering the meters, with consequent condensation of vapor or drying of diaphragm. Thus, under date of October 5th on the chart, the meters were proven immediately after passing 1583 cubic feet of gas which in its passage through the meters was 15° above its temperature at entrance, and consequently there had been a drying effect upon the diaphragms. It will be observed from the chart that the meters most frequently run fast after drying (plus period) and slow after wetting (minus period) of the diaphragms; this was the general tendency of all meters tested. Upon raising the temperature of the meters to an excess of 51.7°, they ran over 8% fast, as shown at the close of the curve. Even in other meters which were constantly kept at a temperature equal to or slightly above that of the incoming gas, and in which, therefore, the latter was continually slightly superheated, the absorptive effect of the heavy diaphragm oil upon the vapors was ultimately such as to cause the same bleaching effects. The meters were in great part provided with glass fronts through which continually the appearance of the diaphragms could be observed, and under the foregoing treatment they all showed bleaching; the passage of two to three thousand cubic feet of gas with a moderately low temperature of meter is sufficient to produce this effect.

These experiments, therefore, fully reproduce the practical phenomena of bleaching and drying of diaphragms, and explain their cause. It is evident, as is confirmed by numerous cases in our practice, that meters which have in every day work been first subjected to temperatures which remove the diaphragm oil, and are subsequently, through house heating or rise of atmospheric temperature, subjected to warming and drying, are liable to register seriously fast. Moreover, a meter



DATE	9-17	9-21	9-24	9-28	10-1	10-5	10-8	10-12	10-15	10-19	10-22	10-26	11-2	11-5	11-9	11-12	12-16	12-23
METER TEMPERATURE (F) + OR – TO INLET GAS	-5°	+5°	-10°	+10°	-15°	+15°	-5°	+5°	-10°	+10°	-15°	+15°	-5°	+5°	-10°	+10°	+3.4°	+51.7°
GAS PASSED, CUBIC FEET	1227	1550	1787	1653	1007	1583	1427	1560	1320	1563	1080	1507	1593	1143	863	1240	1010	2803
GAS PASSED, TOTAL CUBIC FEET		2777	4564	6217	7224	8807	10234	11794	13114	14677	15757	17264	18857	20000	20863	22103	23113	25916

Fig. No. 2,

removed in this condition and proven and adjusted to correct registration with its diaphragms bleached, is liable to be set under conditions such that its diaphragms again become damp from vapors, when it will register slow; also, the leather in this condition being now unprotected by diaphragm oils, is probably much more liable to gradual decay.

Evidently, therefore, to insure constancy of registration and protection of the diaphragm leather, the latter must either be so prepared that its fibre shall not be acted upon by the gas and water vapors, or else the oil or other diaphragm saturating compound must be rendered capable of continually saturating the leather even while acted upon by these vapors.

Although nearly all of our efforts to attain the foregoing results were failures, and, moreover, the method finally adopted for trial is so simple as to warrant very little description, nevertheless a few brief remarks may contain something of interest.

Our first efforts were directed toward the finding of a compound which would not be acted upon by the gas vapors, although we were aware at the outset that this would be a difficult matter. A very great number of oils were tried ; we scarcely hoped to find one which in its natural condition would resist the vapors, the latter being such powerful solvents, but we hoped that we might at least find one which, by special preparation or method of application to the leather, could be made fairly refractory or would render the fibre of the leather less liable to change of form. With some of these oils we had no success whatever under any condition. Certain of the vegetable oils, especially boiled linseed, which is the substance chiefly employed in the preparing of the textile diaphragms which have heretofore been used abroad, were rendered somewhat refractory to the vapors when allowed to partially oxidize after their application to the diaphragm and before the latter is placed in the meter ; even then they would gradually yield to the action of the vapors, however, or under drying action would harden so as to impede the motion of the meter. Various combinations of these oils were tried and various methods of application to the diaphragm, including heating in application and careful seasoning. "Soaps" or greases saponified

together with iron and aluminum, were also tried without success. Shrinking the diaphragms by immersing them in water and then drying before the application of the diaphragm oil was tried. Diaphragms were lightly coated with collodion, which is quite refractory to the vapors, after the application of diaphragm oil, but the bleaching of the diaphragm through this collodion film quite readily took place. "Flexible compound," which is probably a boiled linseed oil preparation, was tried, but behaved largely like linseed oil.

Many materials other than the ordinary sheep-skin were also tried, among them the following: Both plain and glazed kid, which makes an excellent leather, being firm and non-porous and changing its shape less than sheep-skin; it is rather expensive, however, and in view of later developments seems unnecessary of adoption. "Chrome" tanned, and other special tannings of sheep-skin. Very thin artificial leathers, which became too brittle. Various special preparations of sheet rubber. "Dichtungsgummi," a German sheet packing which has nearly the flexibility and elasticity of pure sheet rubber; it is remarkably refractory to the ordinary light solvent oils, showing almost no tendency to dissolve under their action, but it absorbed sufficient of the vapors to expand considerably, which rendered it unsuitable for diaphragm use. Silk, linen and muslin coated with oxidized linseed oil and flexible compound; these, being thin, would work well even with a coating of oxidized oil, but this latter gradually yielded to the vapors, as has been found by foreign users of such diaphragms.

Dozens of diaphragms prepared by the foregoing methods were carefully tried in our experimental appliances, none of them proving at all satisfactory.

Efforts along the foregoing lines having been unsuccessful, other means were sought. It occurred to the experimenter that possibly the capillary action of the leather could be made use of, and investigations were made in this direction.

These experiments showed the diaphragm leather to possess unexpectedly high capillarity; this varied with different oils, but it was found that a light machine oil would in three or four days rise 12 or 13 inches in strips of leather, which is the full height of an ordinary 10-light meter diaphragm. It will

ultimately rise to a height of 28 to 30 inches, but at a much slower rate. In diaphragms, because of their form, this absorption is less rapid than in these strips, but nevertheless a new and entirely dry 10-light diaphragm in the meter will become thoroughly saturated from top to bottom through this capillarity in from eight to ten days. It is evident, therefore, that if sufficient oil be placed in the bottom of the meter for the diaphragm to continually slightly dip into it, the supply of oil upon the diaphragm will be continually quickly replenished even if temporarily removed in part by condensed gas vapors. This is fully supported by the result of our practical experience with a large number of meters mentioned below, it being very rarely the case that a diaphragm removed from the most trying practical service is not found saturated with oil completely to the top. Moreover, even while the oil is thus temporarily partly removed the leather will be wet with condensed gas vapors, and will, therefore, tend to preserve its dimensions and uniform registration.

Experimental meters thus equipped having shown very promising behavior, about 35,000 meters have thus been fitted and put into use during the last fifteen months at Philadelphia.

A comparison of the proofs of these "dipping" meters with the proofs of the ordinary non-dipping meters, after removal of each from service, invariably shows a superiority in the former. Even ordinary meters which had come from the shop within these fifteen months, and whose diaphragms are, therefore, in equally good condition with those of dipping meters, show an inferior performance; 50 of each kind of such comparatively new diaphragm meters recently proven after nearly a year's work, showed an average net proof of .04% fast in the case of the dipping meters and .8% fast in the non-dipping. A comparison of the proofs of all meters of each kind proven from Jan. 1, '06, to date is far more favorable to the dipping meters, the range of fast and slow registration in these being less than half of that existing in the non-dipping meters. In this latter comparison, it is natural that the non-dipping meters should show inferior behavior to the dipping because the latter had newer diaphragms; nevertheless this is the comparison, we believe, which shows most correctly

ultimate conditions as we have good reason to expect that the condition of diaphragms in the dipping meters will for a very long period remain practically the same as when new, whereas, the non-dipping diaphragms are certain to experience injury.

While longer trial is necessary to completely establish the excellence of this method in every respect, we seem, from these results, to have every reason to expect a much improved behavior on the part of the dipping meters. The mere fact that on inspection dipping diaphragms are almost invariably found after service, to be thoroughly saturated with oil, seems to render it positive that serious cases of bleaching will no longer exist, and also, that the diaphragm leather will be much less liable to decay and breakage; consequently, the cases of abnormal slow and fast registration, which are productive of so much loss to the company or dissatisfaction to the consumer, will be avoided, as well as much of the considerable expenditure ordinarily required for meter adjustment and repair.

This dipping oil, even when newly placed in a meter, has no appreciable effect upon candle power through absorption of gas vapors, this being ascertained by direct experiment with meters subjected to even very low temperatures. The oil being upon the bottom of the meter comes in contact with but little of the gas at a time, and any absorption is exceedingly gradual and small.

The oil which we are trying is a moderately light, pure mineral machine oil from which has been removed all traces of whatever acids have been used in its refining. We have chosen this oil chiefly because it is at ordinary temperatures almost entirely inert and unchangeable chemically, having no tendency to become viscous by slow oxidation, or to slowly form acid or other compounds, which is probably not true of vegetable or animal oils. There seems, therefore, no possibility of its having, even ultimately, any injurious effect on the leather. It is also cheap, the cost of the quantity used in a five light meter being only 3c or 4c. It is also absorbed by the diaphragms slightly more readily than any other oil which we have tried. In its pure condition it has a solidifying point of about 35° F., which is a temperature reached by few

meters; moreover, the absorption of even a very small amount of gas vapors by this oil renders it fluid at 23° F., and such vapor absorption occurs after the meter has been in use a very short time. Sufficient oil is placed in the meter to immerse about ⅜ inch of the bottom of the diaphragm, the latter being previously saturated with the same oil. The quantity of oil required for an ordinary five light meter is ten ounces in each compartment, or a total of twenty ounces.

It is necessary, as is usual in the ordinary oiling of diaphragms, to let them stand or "season" for a week or ten days after the application of the oil, before placing in the meter and adjusting the latter; it is better still that the meter be fully equipped with its dipping oil thus stand before adjustment. This treatment seems, from our experience, to be necessary in order that the leather may experience full saturation and assume final shape.

Effect of Friction and Evaporation of Meter Condensation.

In the course of our work questions have arisen which have led to the following couple of experiments. The investigation suggested by them we have been as yet unable to make, and the results are quoted simply as general information which may lead to further confirming experiment by others.

Friction of mechanism appears capable of causing very considerable variation in registration, and care in the packing of stuffing boxes and neat fitting of the links, etc., is worthy of attention. The following experiment is quoted. To the crank rod of a 100-light meter was attached a 3¼ inch diameter pulley, upon the perimeter of which was wound a cord which was acted upon by weights, these being so applied as to successively retard or assist the motion of the meter. A weight of one pound caused the meter to register 8% slow when retarding the motion of the meter, and nearly 7% fast when assisting its motion. It is probable that the chief effect of friction is to slightly change the length of stroke where there is any play of mechanism, and even slight change of this kind can quite appreciably affect registration. This friction effect would probably, therefore, differ in every meter;

this one experiment is cited simply to show general effects. It appears to indicate, for instance, that a meter adjusted with tight or binding mechanism, and which subsequently eases up through wear, will run fast; this agrees with our practical experience.

If a meter contains condensed gas vapors it may still register gas about correctly, the latter being generally saturated with these vapors and having no tendency to pick up the condensation. In the proving of such a meter with air, however, the air readily absorbs condensation, with consequent increase in volume, and the meter is liable, therefore, even if measuring correctly, to apparently run fast. The action in this case is quite complex. The vapor formed will tend to increase the volume of the air, while the simultaneous lowering of temperature through this evaporation will tend to diminish it; moreover, these effects will take gradually while the air is being received and discharged by the diaphragms, and both will be affected by the rate of passage of air through the meter. To ascertain approximately the net result of these various effects in meter proving, the following experiment was made. A number of meters containing meter condensation were proven. The air discharged from the meters was run into another prover and its volume noted, and simultaneously the temperature of the air at the exit from the meter was observed. The meters and all parts of the apparatus were at the beginning of proof at one temperature. On four successive proofs, passing 8 cu. ft. of air on each proof, the average increase in volume of the discharged air as measured in the outlet prover at the constant room temperature varied from 2.9% on the first proof to 1.65% on the fourth proof. The temperature of the air was lowered 7° in each proof in passing through the meter. The net result of these opposed effects was to cause the meters to register from 1% to 1½% fast on the first proof, the error being, however, small after this first proof and diminishing to almost zero on the last. It seems, therefore, that although the maximum error is not very serious, the passage of a few feet of air through a meter before taking its proof tends towards greater accuracy in showing the actual displacement or registration of the meter.

DISCUSSION.

THE PRESIDENT : Gentlemen, you have listened to a most admirable paper. It almost amounts to a text-book on the meter question. It is before you for discussion. Mr. Rusby would like to answer all questions that you wish to ask him.

MR. A. S. MILLER : Mr. Chairman, this paper elucidates in a very clear way a question which I believe has worried, at some time, about all the people in the gas business, as well as a number of the meter makers. We have all been worried at what is commonly termed "bleachers," more so, I believe, in the East, since we began using Texas oil in making water gas, as that seems to absorb the diaphragm oils more readily than straight coal gas or than water gas made from Pennsylvania oils or Ohio oils. There is nothing I can say, Mr. President, that would add anything to this matter. I would like to extend to Mr. Rusby my thanks for the very careful manner in which this is worked up. It will be of immense use to us.

MR. T. D. MILLER : Mr. President, I would like to ask Mr. Rusby if this mineral oil that he refers to in the paper is the only one that he found he could use that has this tendency to saturate the diaphragm through capillarity.

MR. RUSBY: Other oils will saturate the diaphragm through capillarity. As stated in my paper, however, our reasons for using this particular mineral oil are that it is chemically inert and not liable to decomposition at ordinary temperatures, and is cheap. It must be free from any acid used in refining.

A MEMBER : What kind of oil was it?

MR. RUSBY: An ordinary light, pure mineral machine oil.

MR. T. D. MILLER : Mr. President, we had an experience with the bleaching of diaphragm leathers by the gas supplied through our river pipe to Algiers, which was a high pressure service. We first installed for this service wet meters, but we soon discovered the gas was so dry that the wet meters required filling about twice a week. We then removed the wet meters and installed dry meters, but in the course of a few months we found the leathers bleached so badly that they would pass

gas like a sieve. This became a very serious question with us, and I hope that the suggestions of Mr. Rusby will aid us very materially in treating this character of trouble. At the time we used a mixture of oils charged heavily with graphite, which we introduced through the valves and allowed to soak on the inside of the leathers, after which the oil was drained off and the meter put back into service, which gave us fairly good results. If the method of dipping the leathers into oil, while in service, will solve the problem, so far as distribution of compressed gas is concerned, Mr. Rusby has undoubtedly given us a valuable paper.

THE PRESIDENT: Is there anything further, gentlemen? There is a call for Mr. Spangenberg. Is Mr. Spangenberg in the room? If so, we would like to hear from him on this subject.

MR. SPANGENBERG: Mr. President, I was not present at the reading of the paper, but I can verify everything that Mr. Rusby has said in his paper. It is a matter with which I have had some experience. This method of wetting the diaphragms in these dipping meters with oil is certainly a good solution of a troublesome problem.

MR. K. M. MITCHELL? I would like to ask if Mr. Rusby can tell us where this oil can be obtained, and about what it costs per gallon?

MR. RUSBY: It is merely an ordinary good quality light machine oil, such as can be obtained anywhere. I am sorry that I cannot at the moment state the specific gravity. Its cost is about fifteen cents a gallon. Our reasons for using it are somewhat theoretical, but appear good; our experience to date has not been very lengthy, but has been quite favorable. If we find out anything to the contrary we will be glad to make it known.

MR. A. S. MILLER: Mr. Rusby, you know that with some gas men it has always been a sort of superstition that petroleum was bad for leather. I would like to know how long your experience in using petroleum for this purpose has run, and whether you have found any tendency to injure the leather.

Mr. Rusby: We have been using it in some meters for about eighteen months. This, of course, in comparison with the length of life that is expected of a meter diaphragm, is a very short time. We cannot say positively that the oil will not have injurious action upon the leather, but we cannot see any reason that it should.

Mr. A. S. Miller: I see no reason why it should not be entirely satisfactory, but it has been one of my superstitions, which I seem to have grown up with the belief was a fact.

Mr. Rusby: I doubt that any injury will result, but only further experience will determine this. We will be very glad to hereafter make known to the Association, or to any single inquirer, the results of our further experience.

Mr. T. D. Miller: I would like to ask Mr. Rusby if he has tried to use paraffine on any of these meters?

Mr. Rusby: I think we did. We tried this and a large number of similar substances, but all were cut by the gas vapors. The German engineers of whom I spoke in my paper, state that xyelene is a powerful solvent for the diaphragm oils, removing even the refractory oil compounds on the textile diaphragms. Cut holes right through it.

Mr. A. S. Miller: Mr. President, as my neighbor here has just said, this is so new, and this whole subject is following such a different line from anything which was ever followed before that I feel that it cannot be discussed here in the way that it deserves. I have not the slightest doubt that everything will be found just exactly as Mr. Rusby states, but as he states, he is simply stating the results of some preliminary experiments, and it will take time to say whether he is working on the right track. From my own point of view, I should say there was every indication that he has started work on the right track, and on a track that is going to be of very great benefit to the gas industry. This matter of meters being out of proof has been a more serious one in later years than in previous years. I wish, therefore, to move that a hearty vote of thanks be given to Mr. Rusby for the benefit that he has given us of the tremendous amount of work that he has done.

Motion seconded.

Mr. Shelton: Mr. President, before that motion is put I would like to ask that opportunity of discussion be extended to a visitor who has come a long distance, and whom we have the pleasure of having with us here today. He may have some thoughts on this meter subject that would be very instructive for us to hear. I refer to Mr. Thomas G. Marsh, of England, who has traveled some four thousand miles to be with us. While primarily not here on business, he has nevertheless timed his visit so as to be able to be present at this first meeting of the American Gas Institute. I think that the members of the Institute would be very glad to have him say any word which he may wish, and to give us a chance to welcome him. We know that when any of us go abroad, and, first and last, there have been a good many of us that have had that opportunity, and when we have had the good fortune to be present at some of the English meetings, we have both individually and in our association capacity been most cordially welcomed, and I think I scarcely need to say that it is our disposition that we should be second to no one in extending courtesies and a welcome to any accredited, capable, successful gas man, especially one coming such a long distance. Mr. Marsh has been identified with the meter interests for many years. He is one of the authorities on such questions in England, and we have the good fortune in having him with us. I do not know whether he has perused this paper or is in a position to make any accurate criticisms upon anything that Mr. Rusby has said as yet, but I certainly believe that I am right in saying that we would be glad to have Mr. Marsh say any word that he may see fit, and give us any thought that he may have on the discussion of this particular question. (Applause.)

The President: It is with very considerable pleasure that I offer Mr. Marsh the courtesy of the floor, and in doing so I am sure that I voice the sentiment of all of the members of the Institute. We should be very much pleased to hear from Mr. Marsh.

Mr. Thomas G. Marsh, Manchester, England: Mr. President and brother gas men, I thank you very heartily for

what you have said with regard to my fellow countrymen. I have only one regret now that I have come to America, and it is, this being my first visit, that I did not come over here and see you many years ago. If I had, in all probability I might have become as much an American as the most of you that I see around me.

Before I attempt in any way to criticize or speak upon the paper, which, I am sorry to say, I have not had the opportunity to glance over until I came into this room, I must first pay what I consider is a debt due to you. When I came over here I was received in the most broad-minded and generous manner. As a gas man I felt desirous of seeing what was being done in this country, and in the very short time that I have been here I have been received, and welcomed, and shown over various works and plants. At times I might have been a little dense in comprehension, but very great care has been given to make me fully understand the matter. And when I go back to England I shall be able to say that our brother gas men over the water are most broad-minded in that in what they are doing they are willing to show it to a stranger, and I shall say to them emphatically that we in England ought to act in a reciprocal manner. (Applause.)

Now Mr. President, I am sure that I cannot add much to the facts given in the paper. If I can say a few words, however, about one or two points I shall be only too glad to do so. Your great, your mighty country, has been blessed by Providence with many things which we have not ourselves. We have in my own country an amplitude of ore. We have an amplitude of coal, which has helped to develop my country, and to bring it up to the proud position that it holds as being one of the smallest in area and yet certainly one of the strongest in the world. That has come about very largely, perhaps, through the energy of the people, but more so from the country having been blessed with an ample amount of coal, an ample amount of minerals, and to help matters on we had very fair transport arrangements. But when I came over here I find that you not only have coal, but that you have minerals, and that you have natural gas, which comes upward from the earth with but little comparative cost to

obtain it, and which gives you, I might say, millions of horse power in addition with which to light and otherwise use in the many communities of this country where I understand it is found. When I saw that I said "that is one thing that we have not in my country." And when I came west and saw the Falls of Niagara, and I saw what I called God's great art there, and yet beside the falls I saw man's great art also. I saw the mighty power of those falls harnessed and made use of for the purposes of man; harnessed and used for the purpose, I noticed, for one thing, of making carbide of calcium. Now that is a material which we cannot in any way make in England. We cannot possibly get the power at the the price that it is given to you. But having all these helps I find that the men are not slothful as we find in many countries which are fruitful, but that they have the energy to make use of these great natural advantages, and they make the very best use of them.

When I go among you, and meet you, and while I stand in this room, I feel at home. I am among gas men. When I have been in the country on a motor drive, or anything else, and I came within the familiar odor of a gas works it made me feel just like getting home. When I come among you, I feel the same.

Now, I will not take up much of your time to speak about the paper, because I am sure that you have a lot of other business to do. I will refer briefly, however, to the matter or subject of this paper.

I believe that one of the reasons why, of late years, there has been a falling off, perhaps, in the quality of meters when they are taken out as compared with what they were in passed times has been in consequence of the tremendous increase in demand. I am not speaking particularly of your own country in that regard, for I have noticed the same thing in my own. Now, when in England the "penny in the slot" or "nickel in the slot" meter came into vogue, and with which my associate, Mr. Thorp, and I had the honor to be identified as inventors, and which we have had the honor to be the first to introduce, —when that first came into use in England, the meter business was only a small matter of a hundred or a hundred and fifty

per week, but that suddenly jumped up to many thousands. In fact, in the experience of my own concern, Meters Limited, it jumped up from a mere matter of perhaps a hundred and fifty to two hundred hands to a matter of something between two and three thousand hands. Now the work is equally well done. The meter is well finished, but the diaphragms have not had the time to pickle that they should have had. I believe that the diaphragm of the gas meter before it is put in should certainly be allowed to absorb the oil, and that it should be left in store for a matter of six or seven months before it is put into the meter. Now, of course, we can understand that where the demand has increased so greatly, that is a very difficult matter to do. In fact, it is almost impossible. But if a gas man could prepare himself so as to have a very large number of diaphragms ready pickled, and not use them until they have been in pickle at least six months, I think that one of the very serious drawbacks which now exists would be removed.

Then another matter: we should have a meter that is without seams. That is a very important matter in connection with the diaphragm. I agree with the writer of the paper that it is a mistake to wire the diaphragm. They ought to be fastened with stiff cord, but I am also of the opinion that the diaphragm should not have a seam in it. It should not be sewed. It should be cut out in one piece, and it should be so put into the meter that the leather cannot under any circumstances touch the case or any part of the meter. If that is done, then I see no reason why, when the meter comes out, there should be any defect that occurs from the diaphragm.

On the other hand, a very serious matter in meters is the sliding valve. Ordinarily, I have but little regard for the sliding valve at all. There is in many kinds of gas a deposit of oil that gets on these valves. They stick. Much trouble is caused that way.

Another matter is this: Occasionally, where meters are fixed, possibly not so often now as in the early days, there is a certain amount of dirt, or a certain amount of deposit which comes out of the pipe in the building and gets on to the meters, and some of it gradually finds its way into the seat of

the operation of the valve, and the consequence is that that valve becomes more or less grooved, with the result that the registration of the meter is very much affected.

I am sorry, gentlemen, that I have not the opportunity of going fully into this subject. I see that it is mentioned in the paper, although I did not read it fully, as to whether the diaphragm should not be constantly absorbing the oil by capillary attraction. I am very much afraid myself that it would not be absorbed as equally and as fully as one might hope. I believe that one portion of the diaphragm would probably absorb more than the other. Of course, I have not had experience with it. I have been out of the consumers' type of meter business for some ten or a dozen years, and except for the interest that I have in Meters Limited, with which concern I remain in personal connection as to stock holding, but take very little interest in the management. But if I myself was to purchase dry meters, I should certainly specify that the diaphragms have no seams in them.

Now, gentlemen, no man can but feel highly honored at the manner in which you have received me, and which I fully expected after the generous, open-hearted and broad-minded manner in which I have been received since I came into the country. Gentlemen, I can not say what I feel, but I think you understand what I desire to tell you, and how much I have been impressed with my reception. (Applause.)

THE PRESIDENT: Gentlemen, it has been moved and seconded that a hearty vote of thanks be extended to Mr. Rusby for his valuable paper. All in favor of that motion say "Aye." Contrary minds will signify by the same sign. The motion is carried.

Mr. Rusby, you will please consider yourself thanked.

MR. RUSBY: Mr. President, I am very grateful for this evidence of your appreciation.

THE PRESIDENT: Will Mr. Mitchell kindly take the chair?

Mr. K. M. Mitchell assumes the chair.

THE PRESIDENT: Gentlemen, the next on the order of

business is the report of the committee on "The Making of Rates and the Additional System of Costs." (Account of the Western Gas Association.)

MR. W. H. GARDINER, JR.: Mr. President, here is the report of the committee on rates appointed at the last meeting of the Western Gas Association, the committee consisting of Mr. Doherty, Mr. George McLean and myself. I would like to preface the reading of this brief report by saying that in preparing this material we felt obliged to depart from past methods and to treat the subject primarily in an abstract way, confining ourselves to laying down what seemed to us perhaps to be the best lines for subsequent detailed elaboration rather than to attempt in one report to adequately cover the subject in general, especially in view of the fact that the committee was appointed but six months ago. We have not attempted the formulation of any final conclusions on this very intricate subject.

REPORT OF COMMITTEE ON RATES.

The first action of your committee was to collect a bibliography of 215 references on the subject of rates, prices and costs. This bibliography is appended and is the result of correspondence with the Secretaries of 20 gas associations, 33 electrical associations, 3 gas and electrical associations, the the editors of 3 technical journals and 6 individuals. The committee would here express their great obligation to these many gentlemen, who, by their hearty co-operation, have enabled your committee to present this valuable bibliography. The Committee earnestly requests those who may note omissions from this list to advise the Secretary of the American Gas Institute thereof to the end that this list may become a complete reference to the principles and methods of public lighting rates. The investigation to date has been confined to the United States, Canada, Great Britain and Ireland, but may be extended to other countries should it be deemed expedient so to do.

Method of Procedure.

Considering this as an initial report your committee deems its duty to consist in an endeavor to inaugurate steps to an ultimate solution of this great problem in the light of the large amount of very valuable but disconnected work done by others. Its object is to formulate that rate system which will give the public the maximum public lighting service at the minimum cost to the public and at the same time return to the company a net profit commensurate with the service rendered. This rate should be equitable to all concerned. It should be reasonable, simple and popular. It should be legal under the law and in the light of such opinions as might reasonably be expected from a true understanding of rates by the courts.

Such specifications may on their face seem contradictory, but your Committee's method is not at the outset to affirm or deny what is possible or impossible. Its object is rather to first formulate that rate system which will best serve the public and the company solely from the economic or monetary standpoint, to formulate the best business-getting rate. If this can be produced, it will then be time to say how it must be modified to conform to other exigencies. But if all factors are always simultaneously considered, their individual perfection is impossible, and, therefore, they can, none of them, ever be truly balanced, so that the products be as good as possible.

For these reasons, your Committee has set itself against the immediate consideration of the many present forms of gas rates, with their many items, as meter charges, uniform rates, customer charges, demand charges, etc., etc. These are the compromises arrived at to date. They are attempts to solve the rate problem under specific conditions, but do not necessarily pertain to its principles.

These principles are so intricate, that to consider them collectively would perhaps but confuse the issue. Therefore, your Committee recommends that the problem be studied under four separate headings, as follows:

First.—Economic Desirability: Those rate principles and conditions which, apart from any other considerations, will give the public the maximum service at the lowest price compatible with commensurate net earnings to the company.

Second.—Equity: Those principles which constitute true equity, individually and collectively, to all concerned.

Third.—Sociological Expediency: Those public conditions to which Economics and Equity must be subordinated.

Fourth.—Legality.

It is the hope of the Committee that when the principles and practice of rates shall have been considered under these headings, *separatim et seriatim*, a product may be evolved which will have some degree of acceptability and of permanency.

Setting aside, therefore, the three last-mentioned items for possible future consideration, the Committee has proceeded to a preliminary consideration of the first.

Economic Desirability.

The problem is, first, to determine solely those principles under which a rate can be developed which will enable the public to obtain the maximum service from a public lighting company on terms fair to the latter, and, second, to state the conditions and terms of such a rate.

Assuming on the part of the seller the ability to produce, deliver and sell commodities or services, and on the part of the buyer the desire for the commodities or services and the ability to pay for them, there are two balancing factors of equal importance in the determining of the ratio of exchange, price or rate, as we call it.

These are first: the total gross, individual, or average cost to the seller; and second, the total value or worth to the buyer of the specific service or commodity as limited by his desire for it in view of other means of obtaining equivalent commodities or services to meet the same ends.

In order to be in some degree mutually profitable the rate of an exchange must in the ultimate lie between these limits at least on the average. In order to be equally profitable to both parties to the trade, it should lie half way between the cost to

the seller and the value to the buyer. Therefore, in order to arrive at such a rate, as specified, not only must the cost of the service be determined, but also its value to the community as limited by other more expensive means to the same ends, such as a municipal lighting plant.

With this theorem as a basis, it becomes obvious that such a rate system as is sought would obtain revenue as follows: It would charge each customer or for each unit of service no more than the price at which equivalent service could be obtained. It would not charge for any service less than the net additional cost of performing it. Between these limits it would charge at such rates as to meet in each case the individual costs occasioned by each and every individual item of service, but in such a way that the total cost of rendering the service be met in full and a net gain be shown the company equal to the saving the service effected for the customer or customers over the costs of otherwise obtaining equivalent service.

This involves several separate lines of procedure, as follows:

First.—A conclusive analysis and statement of all items of all costs.

Second.—A parallel statement of the value of the service.

Third.—The balancing of the collective and individual costs and values in such a manner as to produce the desired result.

Your committee appreciates the great value of much of the work done in the past on methods of accounting, and especially the more recent and novel work done in connection with new methods of cost finding in the industrial as well as in the public service fields.

A review on their part of some of this work had led to the conclusion that, like attempts to solve the rate problem, much of it has been in the nature of an endeavor to expound and advance special or individual methods rather than to correlate and evolve a final system. Your committee therefore earnestly recommends that before any other steps are taken toward a solution of the rate problem, thorough and if possible conclusive work be carried out to determine the true economic

factors of cost in the gas business and their interrelations and relative importance. The members of your committee sincerely hope that they or another committee will be entrusted with this work to the end that the program suggested in this report may be carried out with such modifications as may be suggested.

Every member of the committee deeply regrets that in this their initial report, they have been unable to come to any more advanced or final conclusions. They would however express their opinions as individuals that the rate problem cannot be solved by the simple method of dividing costs by sales and arbitrarily adding a supposedly fair average profit. They furthermore would express the hope that the present rapid growth of differential rates as alternatives or successors to the primitive and pernicious uniform rate by meter will continue.

In conclusion, they would say that while this report may not seem definite, they have clearly in mind the principal steps they would take to evolve that rate system which will equitably, expediently and legally give the public the maximum service as cheaply as possible with a fair return to the company.

Respectfully submitted,

W. H. Gardiner, Jr.,
Henry L. Doherty,
Geo. McLean.

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MR. W. H. GARDINER, JR: I would like to add one word in conclusion. When this work was undertaken I opened up correspondence with the secretaries of, I think, all of the gas associations, and all of the electrical associations of this country, Great Britain and Ireland, and I want to say just one word as to the hearty co-operation that I received in the work, both in this country and from very many gentlemen in

England, and notably so, for instance, from Mr. Helps, of Croyden, England. He wrote me a ten or fifteen page letter, which was a very valuable contribution indeed on the general rate situation in England. I mention his among many valuable contributions from England merely because his name happens to come to my mind.

Another thing, many of these gentlemen in answering requests for papers and information on rates, have asked that a copy of the report be sent them when it is published, simply for the bibliography contained therein. The bibliographic part of the report contains some 215 references to rates, and also contains quite a large number of references to legal opinions and decisions on the rate question. These gentlemen who have co-operated in making up this report would like a copy of it.

THE PRESIDENT: Gentlemen, you have heard the reading of this report. It is a very valuable contribution to our work, and we would be glad to have as free a discussion on this most important subject as possible. We would be glad to hear from the other members of the committee. Is Mr. McLean in the room?

MR. D. MCDONALD, Louisville: Mr. President, it is suggested that this matter be left to the committee. It seems to me that this matter brings up the whole question of the relation of the gas company to the public and to the authorities, because when you come to fixing rates you find that you are hedged around with legal restrictions, and sometimes with constitutional restrictions. I, therefore, make a motion for the appointment of a committee, and for the reference of this subject to that committee. I make the motion in this form, Mr. President: That the incoming President of this Institute be requested to appoint a committee of seven members to be known as the "Public Policy Committee," this committee to be charged with the consideration of all matters relating to the relations of gas companies to their patrons, and to the public authorities.

Motion seconded.

MR. SHELTON: That being seconded, Mr. President, I

should like to say that I do not want to be appointed on that committee.

MR. D. McDONALD, Louisville: I did not contemplate you, Mr. Shelton. So you need borrow no trouble on that account. (Laughter.)

MR. SHELTON: It seems to me, Mr. President, that that Committee is charged with a tremendous undertaking if they are to report on "all questions of public policy," and, furthermore, I sort of hate to see this increase in the number of committees. It seems to me that we have about enough of them now. It seems to me that we had better try to hold down the number of them, unless we have some specific work for a committee to do. It would seem to my mind, Mr. President, that such a committee would of necessity have to work on very general lines, and before any such motion is approved, I should like to hear it discussed further, and to have some information given us as to what it is specifically proposed to have the committee do.

MR. D. McDONALD, Louisville: In answer to that, Mr. President, I have only to say that I have used this paper as the occasion and not as the cause of making this motion. In the fifty states, or in nearly every one of them, the authorities are considering, more or less all the time, matters which are directly affecting our business. Now, my idea is that this industry ought to have an organization through which it can speak, at least through which it can speak to its own members, and can instruct them as to what is to their interest. An organization that can point out bad laws, and can point to states which have adopted better laws. If there is any committee or body in this Association which has been given such a duty to perform, then I will withdraw this motion. If there is not, then I insist upon it, because I think we ought to be able to act as a unit and to act intelligently in regard to many of these matters which are coming up, and which are of very vital importance to the gas industry.

THE PRESIDENT: Gentlemen, you have heard the motion, or the resolution offered by Mr. McDonald. Are there any remarks?

Mr. W. H. Gardiner, Jr.: Mr. Chairman, the question has been raised, as I understand it, as to whether there was a definite fixed field of action to be left to such a committee. It seems to me that there most assuredly is, and I would like to mention as among the subjects which might be spoken of off-hand such topics as the question of taxation, the question of rate regulation, the entire question of government control. These are items of critical and even vital importance to the industry we represent. I think such a committee, if it were a live committee, and composed of strong, able, broadminded men, could work in that field, and theirs would be a work of very great value to the gas industry.

Mr. Shelton: Mr. Chairman, I do not wish to be understood or construed as underrating for one minute the importance of this subject, but by referring "all questions of public policy" to a single committee is certainly going to impose on that committee a mass of work and a mass of responsibility that is scarcely fair to expect a single committee to cope with. The questions are so diverse that it would require many committees in order to give them adequate consideration, and it all leads up, after all, into the broad question of the work of the Institute. Mr. Gardiner is right in saying that these questions which he speaks of are all important questions which have only been partially met heretofore, but my thought is that a single committee is an insufficient tool to meet all these questions. It comes right back, as it seems to me, into a question of policy. We had better settle first the ways and means by which the expanding work of the Institute is to be taken care of—whether it is to be divided into different departments. Among these, one which he mentions would fall into the department of a legal nature. The question of taxes is really of that nature, and the question of rates is in that same category.

At any rate, before this is voted on, I should like to hear what the duties of that committee are to be so that we can get that a little more clearly in mind.

Mr. McDonald, Louisville: My point is to have an organization which can have these matters before it. That knows when

hostile legislation is proposed. It is not expected that the committee will do any lobbying, but it could point out where a particular law works badly, and point out where a better law has been passed, and worked well, and that is just exactly what the individual gas man living in any one city wants to know, so that when a critical time comes he has some resource to fall back upon.

MR. W. H. GARDINER, JR.: Mr. President, if I may be allowed another word in connection with this committee. I do not know as Mr. McDonald had in mind a committee that would take up active work outside so much as a committee that would study these questions and formulate them, prepare the work beforehand, foresee crises before they arose, and work up the material and means of meeting coming difficulties. It seems to me that that would be the field of work of such a committee. And in such a field, it seems to me, that this proposed committee can undertake such work, and can do as much as it is in its power to do within the scope of its work, and the time at the command of the committee. Personally, I did not have in mind that it was to be a committee to do outside active work, having rather in mind a preparatory or student committee that would think over and formulate these many vital matters of public policy.

MR. DOHERTY: Mr. President, I may be able to throw a little light on this, although I do not know that I can. A similar committee exists with an organization with which I am connected, an organization dealing with questions concerning corporations interested in quasi-public service. Whether this could do the work on the same general lines of this committee of this other organization I refer to I do not know, but this suggests that something should be done in this line for our fellow gas men. In the particular association of which I speak a committee has been formed of five or seven men, I do not remember which. They have taken men who have had a natural interest in a particular business or line of business, and they have taken the men that they believed had the widest view of the entire country in regard to the relations of the quasi-public corporations to the public, and they expect

that committee to anticipate the classes of difficulties which quasi-public corporations may have in their future experience, and by anticipating them or foreseeing them to prepare for them so that they may be met successfully. I would urge the appointment of a committee of that sort, and especially that the committee should be in touch with other quasi-public service corporations, so that they can work with them.

THE PRESIDENT: Mr. McDonald, will you kindly state your motion again?

MR. D. McDONALD: Mr. President, I will read it: "That the incoming President of this Institute be requested to appoint a committee of seven members to be known as the 'Public Policy Committee,' this committee to be charged with the consideration of all matters relating to the relations of gas companies to their patrons, and to the public authorities."

THE PRESIDENT: That motion was seconded, I believe. You have heard the resolution offered by Mr. McDonald. All in favor of this resolution will signify by saying "Aye." Contrary minds will signify by the same sign. The "Ayes" have it, and the committee will be appointed.

MR. EGNER: I want to make a suggestion, Mr. President. It should properly be made, perhaps, to the incoming President. I listened with great attention and interest to what Mr. Gardiner said at the Cleveland meeting, and to what he has read here now. I am not joking at all when I say that I believe he is the best qualified man to work this matter up that we have before us now. I believe he has taken the thing to heart. I do not wish to flatter him at all, but I read his paper presented at the Cleveland meeting, and have listened to what he has said here, and what I have heard here has only confirmed my opinion that, as it seems to me, he is the best fitted of all I have heard on the subject. The suggestion which I desire to offer is, that Mr. Gardiner be appointed as chairman of a committee to continue this work, and to report at our next meeting; and, as Mr. McDonald has just now suggested to me, that one man alone would not carry so much weight as when others would be associated with him, I believe

that if a few men of influence, importance and ability were appointed with him on that committee, we would have something worth while on the subject at our next meeting. If I might suggest, I would propose that such men as Mr. Doherty, Mr. Shelton, and Mr. Walton Clark be placed on said committee. These gentlemen would carry weight, and probably refer the work to be done back to Mr. Gardiner; and so it would be all worked out in good shape, and everybody be satisfied in the end. I hope that this suggestion can be acted upon, Mr. President.

THE PRESIDENT: The incoming President, Mr. Egner, will certainly read your remarks and will act, I am sure for the best interest of the Institute.

MR. A. S. MILLER: Mr. Chairman, do I understand that that report was referred to this committee or has there been any action on the report?

THE PRESIDENT: Nothing has been done on the report.

MR. MILLER: Then I move, Mr. President, that the report be accepted and the committee continued.

Motion seconded.

THE PRESIDENT: All in favor of the motion signify by saying "Aye." Contrary minds signify by the same sign. It is carried, and the report is accepted.

I believe, Mr. Dunbar, that you have a telegram there that was to be read.

"SAN FRANCISCO, CAL., Oct. 17, 1906.

American Gas Institute,
Auditorium Hotel, Chicago, Ill.

Congratulations and best wishes. May you live long and prosper.

E. C. JONES."

THE PRESIDENT: Is Dr. Harrop ready to read his paper? If he is here, will he please come forward and read his paper.

DR. HARROP: Mr. President, the report to the Gas Insti-

tute is embodied and printed in this pamphlet, which has been distributed through the room.

REPORT OF THE BOARD OF REVISION ON DISTRIBUTION OF GAS.

General Progress Report of the Board of Revision.

This work was inaugurated at the 1904 meeting of the Ohio Gas Light Association at Cleveland, when it was proposed to organize a board to revise the Question Box (consisting at that time of two volumes) and combine with the condensed matter material from outside sources to frame up the beginnings of a gas compendium, or what we hope and now believe will grow in the course of years with the general co-operation of the gas fraternity into an encyclopedia of the gas industry. During the year between March, 1904, and March, 1905, a board of 18 members was organized, and the task of laying out the forms and methods of procedure was completed. The work of interesting all the associations and certain practical and scientific authorities was undertaken with a good measure of success, and the revision of the first and second issues of the Question Box was partly in type, when external causes outside the control of the board brought the printers to a halt.

With the exception of those actually engaged on the revision no one can realize what an immense undertaking it has been. And it should not be forgotten that the work was done at odd moments by men whose time was fully occupied by their regular pursuits.

The arrangement of the material into some definite order was a problem of the first importance. The selection of a suitable classification required much thought, and special attention is called to that finally chosen.

After a study of the chief text-books, beginning with King's Treatise, and of some "change order" classifications familiar to gas men, a classification was outlined, which, after being tried out in the first compilation of the revision material, and undergoing some changes finally took shape as below :

Coal. Kinds, sources, examination, storage, handling.

Carbonizing (or Retort House). Benches, carbonization, charging and drawing, operation of a retort house as a whole.

Condensing and Scrubbing. Theory, construction and operation.

Purifying. Chemistry and operation.

Other Gases Than Retort Coal Gas. (a) oven gas; (b) wood gas, rosin gas, oil gas, etc.; (c) natural gas; (d) producer gas, such as the regular form and Mond, Dowson, etc.

Water Gas. Theory, construction and operation from handling fuel up to purification.

General Operation of Gas Works. Enriching and mixing gases, testing finished gas, metering, storage, power, and gas works machinery.

Residuals. Coke, tar, ammonia, sulphur and cyanide, carbon, lamp black, waste heat, etc.

Distribution. Distribution problems, gas flow, pumping gas, governors, mains, services and house-piping, construction and maintenance.

Meters. Design, construction, installation and maintenance.

Appliances. Lighting, cooking, heating, water heaters, industrial and power.

Sales of Gas (and Commercial Policy). Desirable and undesirable business, keeping existing business, getting new business, relations with consumers, collections.

General Commercial and Engineering Considerations. Accounting and record in general, general business policy, labor, administration, legal, rates, taxes, educational.

After the classification and method of revision had been fully considered and outlined sections of the work were assigned each to the proper revisor, and thus each became responsible for the completion of the first draft of his own

section. Prior to this the many references to current gas literature contributed as answers to the Question Box had been locked up; and abstracts bearing on the various subjects, together with other references procured independently, accompanied the assigned matter. After the revised sections had been completed they were exchanged among the members of the board and subjected to further scrutiny, so that the accuracy of no single statement should rest with any one authority.

The work done on the revision has not been done merely by the members of the board. It was planned to interest every gas man known to have special experience in any detail of the industry. Aside from the correspondence carried on from the office of the chairman, the sections took up the same style of campaign. The spirit in which the members of the gas fraternity and scientific authorities, both at home and abroad, met these advances has been most gratifying.

The question and answer form is not used in the revision. Instead, the material is distributed among the definite number of topics, beginning with coal in its relation to gas manufacture, and ending with the most general commercial considerations, following the order of a logical discussion. The topics have been kept distinct one from the other to facilitate criticism and further revision. There is no special section for purely scientific matters, these, along with costs, etc., being distributed through the work and treated immediately with the operations to which they relate.

Material drawn from the Question Box, from the proceedings of the various home and foreign gas associations, from works of reference and technical magazines, and personal contributions specially made by others than the members of the board, are carefully credited both in justice to the authors and to enable anyone to trace back to authorities.

It will be worth while to reproduce an extract from a recent letter sent out to some of the members. "The original notion was that the board should take the Question Box, cut out all the duplicated, superfluous or erroneous matter, re-arrange what was left, and then add (from the existing literature of the gas industry and from the experience of the members of

the board) notes to round out the subjects treated. The idea was that the new material brought in by each yearly issue of the Question Box would constantly increase the size and value of the Revision, which was to be made over each year.

"From this starting point our aim expanded until we decided to lay the foundation of a complete treatise on gas manufacture, and this we ultimately hope to attain, not this year, or next, but after repeated efforts. The material contributed to the first four issues of the Question Box has been very full and valuable on some subjects and very meagre on others, and we found that if we confined ourselves to the material suggested, the discussion would be as disjointed as a dictionary.

"What we are trying to do, then, (say in the case of this Distribution section) is to outline a complete, logical treatise on the subject, and fill it in as fully as we can this year, but not overstraining ourselves to make it complete in this edition, because we know that we will have a chance to add to it in the later editions.

"The material on Distribution that is to be found in the several issues of the Question Box is to be incorporated so far as it is of use to us, crediting each bit of information or opinion to the contributor as accurately as possible—generally using quotation marks when the exact wording is taken.

"But while the Question Box was the starting point of the Revision, and while we are using and will continue to use as much of the material from it as possible, it should be clear that the Revision *is not the Question Box*, nor even a revised version of the Question Box, but aims to be (and will be in the course of time) a revised, up-to-date version of gas literature and lore as a whole. * * * Above everything else we must be fair. We don't want to let anything that is undoubtedly wrong appear in the Revision, but we have to remember that there are many variations in practice, and there is usually some bad and some good in each."

In conclusion, it will be sufficient to say that the work was rushed up to the 1905 meeting of the Ohio Gas Light Association in expectation of publishing in time for that meeting. Since then the work has proceeded in a much more leisurely

and careful manner, making excellent progress in some sections. The procedure since that date has been to merge the original revision volume with the matter newly condensed from the 1905 and 1906 issues of the Question Box and the resulting compilation together with additional matter gathered as before from other sources is steadily growing in value.

I will merely mention certain sub-committees of the board, whose work was presaged in former reports: the Select Test Methods Committee, the Coal Mapping Committee, and the Indexing Committee. The first mentioned is tolerably well known.

The members of the board who have been appointed and reported to date are:

J. D. Shattuck, manager, Suburban Gas Co., Chester, Pa.

Henry I. Lea, producer engineer, Westinghouse Machine Co., East Pittsburg, Pa.

Dr. F. Schniewind, general manager, United Coke & Gas Co.

*Chas R. Faben, Jr. general manager, Toledo (Ohio) Coke & Gas Co.

J. T. Mason, superintendent, Third Ward Works, Milwaukee (Wis.) Gas Light Co.

Fred Bredel, gas engineer, The Fred Bredel Co., Milwaukee,

S. Tully Wilson, manager, Improved Appliance Co., Denver, Colorado.

A. B. Slater, general manager, Societè Anonyme du Gaz, Rio de Janeiro, Brazil.

Dr. H. B. Harrop, chief chemist, Milwaukee (Wis.) Gas Light Co.

F. W. Stone, manager, Ashtabula (Ohio) Gas Co.

C. S. Lomax, superintendent, Sharon Coke Co., South Sharon, Pa.

Byron E. Chollar, engineer, Kansas City, Mo.

Henry L. Doherty, Henry L. Doherty & Co., New York City.

W. E. Steinwedell, secretary; Gas Machinery Co., Cleveland, Ohio.

Irvin Butterworth, general manager, Detroit (Mich.) City Gas Co.

Mastin Simpson, Kansas City, Mo.

*Deceased.

G. W. Mead, Union Carbide Co., Chicago.

Geo. C. Hicks, Jr., engineer, P. H. & F. M. Roots Co., Connersville, Indiana.

J. B. Klumpp, inspecting engineer, U. G. I. Co., Philadelphia.

H. G. Stillson, superintendent Distribution, Western United Gas & Electric Co., Aurora, Ill.

W. B. Tuttle, general manager, San Antonio (Texas) Gas Co.

With reference to the present publication, dealing with the Distribution of Gas, it is my duty and my privilege to call attention to the magnificent work done by Mr. F. W. Stone as chairman of the Distribution Section. It was only on receipt of notice calling the first meeting of the Institute that it was decided to print this section, and less than six weeks' time was allowed to mould the material into shape for the printers. Mr. Stone has not only clearly grasped the general methods laid down for the prosecution of the revision, but has brought to the task an ability for analysis and classification that is of the utmost importance here. It must not be forgotten that this is the pioneer section of the revision; other sections that will be put forth later will be in a position to profit by the organization embodied in this, and will entail less labor because of the thought and work that had to be put into this section, in the nature of the case. No text-book of distribution has ever before been written, and I bespeak for this one honest criticism, remembering the difficulties under which it has been brought out, and the co-operation of every man interested in the subject, to make the next edition better still.

H. B. Harrop,
Chairman of the Board of Revision.

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MECHANICAL ASPECT OF DISTRIBUTION.

General Aspect of Distribution.

1. *The Fundamental Problem of Distribution.* Given a network of pipe mains in a town having no marked differences of elevation, and assuming no consumption or leakage, it would be a simple thing to raise and maintain the same pressure at all points in the mains without regard to the location of the gas works. The whole problem of gas distribution arises from the fact that it is not a question of static pressure, but at keeping up pressures at distant points towards which the gas is flowing because it is escaping there through gas-consuming appliances; and since the gas will flow through the

mains only when the pressure is greater at the point or points of entrance than it is at the points of consumption, it is evident that the pressure in the areas near to the source or sources of supply will naturally be in excess of that in areas which the gas reaches after a longer travel. If the rate of consumption grows to be any appreciable part of the capacity of the pipes, a marked drop in pressure will appear, and the desired uniformity of pressure over the entire network of mains will suffer the more as the rate of consumption encroaches on the capacity.

The early distributors of city gas aimed to have a large surplus of main capacity and control pressures at all consumers' premises by regulating the pressure at the works. This system of distribution (based on a practically uniform pressure condition over the entire town and subject to control even up to the consumers' appliances by means of regulation at the works), has since been the prevailing type of distribution. The customary pressures carried averaging two or three inches of water column (about one-tenth lb. per square inch), in this type of distribution have led to its being called Low Pressure in contradistinction to the High Pressure type introduced only in recent years and carrying pressures usually ranging from 20 to 30 lbs. per square inch from the works to the consumers' premises and there reduced by individual pressure regulators on each service. Of course pressure on the consumer's appliances in this case is independent of control from the works; and further, since the individual services are guarded by regulators, great inequalities and variations may be allowed to occur in the street piping without interfering with the smooth working of appliances.

Most of the gas-burning apparatus in existence to day and working on city gas is designed for the pressure of two or three inches water column employed in the ordinary L. P. distribution system, and as a rule will not work properly except within such narrow limits. It is chiefly for this reason that, in the L. P. system, it is of great importance to keep the same pressure in all areas, and of even more vital importance to keep that pressure constant. Inequalities among different areas, and variations in any or all areas hour by hour, both

result from an unsatisfactory relation between capacity and consumption, but the latter especially from variation in the rate of send-out and efforts made to correct for it by regulating pressure at the source of supply.

In addition to the limitations of existing gas-burning appliances, which cannot operate satisfactorily to the consumer on insufficient pressure or excessive pressure, and are pretty sure in either case to give rise to complaints of poor service or "bad gas," we have to remember that the pressure carried bears relation to the loss of gas by leakage, to the strain that consumers' meters will stand, the cost of pumping gas, and the storage capacity of the mains. The ideal pressure that should exist at the head of consumers' services is discussed '03—Q. B.—126, 106 and 123, and '06—Q. B.—516, and seems to be about 25 tenths water column, with a minimum variously stated as 20 tenths, 16 tenths, and in one exceptional case, 10 tenths. As the maximum pressure that should ever exist in a main directly supplying consumers, W. Forstall ('06—Q. B.—557) gives 45 tenths.

For natural gas, 6 ounces, say 100 tenths, is generally accepted as satisfactory. The consensus is that the ordinary tin meter may be used safely at a pressure of 1 pound, or 28 inches water column, providing the pressure is not subject to sudden fluctuations.

Allowable variations in pressure consequent on variable consumption are stated all the way from the extremely conservative figure of 10% of the minimum up to 100% of the minimum (05—Q. B.—564). Eysenbach (same reference) states that an absolute variation of 1 inch is allowable and reasonable, but points out that a variation of 3 or 4 inches in the neighborhood of the works, though not good practice, is common. "With 2.5 inches for an ideal figure, pressure should not be allowed to get higher than 4.5 inches and not lower than 2 inches." ('06—Q. B.—516.)

There is recently a general tendency toward a slightly higher mean pressure throughout the streets than was formerly considered good economy.

2. *Methods of Attaining Suitable Pressure.* The momentary rate of send-out varies with the time of day, the days of the

week, holidays, the weather and the seasons; it is also influenced strongly by the different classes of consumption, lighting consumers pulling heaviest in the early hours of the evening, cooking consumers at meal times, and industrial during the working hours of the day. For the same reasons the areas of greatest consumption shift somewhat about the town.

The capacity that the mains must have depends less on the total amount of gas delivered during the year than on the maximum demand, or the magnitude of the peaks in the load curve. Capacious mains installed to take care of the peaks tend more or less to lie idle during the valley periods, but the interest on the full capital investment goes on unabated, as does also the depreciation. All this is influenced largely by the foresight used in planning, and as a basis for estimating it is imperative to have a good approximate notion of what the average maximum demand per consumer will be. In '03—Q. B.—112, Doherty discusses three sets of load curves and sums up thus: "I would assume from my present available information that in figuring the maximum demand for ordinary domestic consumers it should be 100 feet per hour for one consumer. Where two customers are supplied from the same main it is hardly likely that their peaks will occur at the same time, so in planning distributing pipe it would not be necessary to allow more than 75 feet per hour per consumer. As the number of customers supplied by the same pipe is increased, the maximum demand can be diminished, the greater the number, until only 20 feet per consumer must be allowed."

When the existing mains begin to prove inadequate as the town grows it is time to replace them with larger mains, or to put in one or another of the various types of feeder systems, or else run the pressure up on the street mains and install individual regulators on the services wherever needed.

Replying to question whether the last mentioned method is desirable if the cost of regulators can be kept below $2.00 per service ('04—Q. B.—104), Walton Forstall says: "This question cannot be answered "Yes" or "No" as an abstract proposition. The sole idea of a service or house regulator is to insure the supply of gas under proper conditions of pressure.

If such conditions do not exist at the head of each service, in other words, if the location of the works, or the size of the mains, either or both, is such that some or all of the consumers are subject to more than permissible variations of pressure through the 24 hours, then it is a question of relative economy in first cost and operating expense, whether the proper pressure regulation be attained through service regulators or through changes in the main system. It is easy to be seen that where the services are very numerous per mile of main, a charge of $2.00 per regulator, with say 25 cents as an annual operating charge, would make the regulation of pressure by means of a better main system the more economical method."

A property operating in one city two or more gas works widely separated has a distinct advantage, in that distances and the dimensions of the regions to be served by one works are diminished. This same end is sometimes accomplished, where there is only one works, by erecting a district holder at the further extremity of the town and pumping gas from the works into the holder through a special, independent line; the holder then feeds its own neighborhood.

A still more satisfactory mode of practice, and one that has found wide application very recently, is the "loop" or "spine" booster system. An independent line starts from the works and pierces or encircles the areas of greatest consumption, branching if need be to reach isolated districts, and gas is pumped into this line at 10, 20, or more inches pressure, depending on the conditions, to be fed out into the street mains through governors located at strategic points and set to maintain in each case the pressure found most desirable around that point. This has the virtual effect of subdividing the town into a number of districts of more reasonable area. Properly planned and operated, such an arrangement gives a uniformity of pressure on consumers' apparatus only surpassed by an equipment of individual regulators on each service. Another of its advantages is that with a uniformity of pressure in the network of street mains and the resulting absence of areas of excessive pressure the gas lost by leakage is diminished.

In the average city, the booster line has to be kept under pump pressure only during peak periods, and the cost of

pumping is limited by the hours when re-enforced pressure is required. The amount of pressure to be raised by the pumps is only that necessary to get the gas to the district governors with sufficient excess to operate them as set; this feature is naturally an advantage in point of operating cost over the true H. P. type of distribution.

3. *Flow of Gas Formulae.* The importance of a wholly trustworthy formula to express the relations existing among quantity of gas, length and cross-section of pipe, and inlet and outlet pressures can hardly be overestimated. The most commonly used formula was derived by Dr. Pole upwards of fifty years ago, chiefly from an analytical consideration of certain accepted laws and constants of Mechanics. The Pole formula has proved more than reasonably accurate within the limits of diameter, length and pressure contemplated by its author. For the more recent conditions (referring particularly to high pressures), it has been found necessary to produce other and special formulae to fit special cases. It seems within the bounds of possibility that a formula so complete as to fit all cases may be deduced in time, but thus far it has not been done; and a variety of special formulae are in use, the user as a rule accepting the one he is employing as perfectly general. Nearly two years ago Mr. Shattuck undertook to collect these so far as possible for the Board of Revision, for purposes of comparison, and looking ultimately to the derivation of a general formula. He writes: "I feel that this resume is not by any means complete and that considerable further study can be put on it to good advantage in the future; and I will undertake to devote some time to this subject each year and keep it up to date. I find that the great trouble in using the various high pressure formulae is that care must be used to understand the characters, which may mean entirely different things in the different formulae. They vary in this particular in most every instance, and range from gauge pressure in pounds to absolute pressure in feet of water, from cubic metres per second to cubic feet per hour, and from length in feet to length in miles." It is to be noted that a long step has been taken toward uniformity of symbols, and the attached list indicates clearly the powers of the several letters and signs.

Q = cubic feet delivered per hour.
P_1 = absolute initial pressure (14.7 + gauge pressure.) lbs. per sq. inch.
P_2 = absolute terminal pressure in lbs. per sq. inch.
p_1 = absolute initial pressure in lbs. per sq. in.
p_2 = absolute terminal pressure in lbs. per sq. in.
D = inside diameter of pipe in feet.
d = diameter of pipe in inches.
L = length of pipe in miles.
l = length of pipe in yards.
l_f = length of pipe in feet.
W = Specific gravity of the fluid when Air = 1.
c = constant.
π = 3.1416.
T_0 = absolute temperature at maximum density of water $461 + 37 = 498°F$.
T_1 = absolute temperature of gas after delivery.
T_2 = absolute temperature of gas flowing in main.
g = specific gravity; air = 1. To correct formulae for other specific gravity than that given multiply result by:

$$\sqrt{\frac{\text{g in formula}}{\text{g of other gas}}}$$

In following formulae I have substituted the above designations so that they may be more easily compared.

Pittsburg Formula. This was furnished through the courtesy of Peter Young. (It assumes a gravity of 0.6, which is that of natural gas.)

$$Q = 3450\sqrt{\frac{d^5(P_1^2-P_2^2)}{l_f}}$$

Cox Formula, from which Cox's gas flow computer was calculated, assumes a specific gravity of 0.65 and was furnished through the courtesy of R. B. Brown.

$$Q = 33.3\sqrt{\frac{d^5 x (p_1^2-p_2^2)}{L \times W}}$$

F. H. Oliphant's Formula, as given in his report on natural gas in 1902 (advance pamphlet of U. S. Geological Survey, page 20, see Progressive Age, June 1, 1904, page 269), is adapted for an 8 inch natural gas main and specific gravity of 0.6. For any other size main $d \times \frac{d^3}{30}$ is substituted for d^5, which allows for greater delivery from large mains. For a gas of any other specific gravity, $0.6 \div g$ is inserted as a factor under the radical. The reference above given contains a table for facilitating the use of the formula.

$$Q = 42\sqrt{\frac{d^5}{L}(P_1^2 - P_2^2)}$$

Prof. Robinson's Formulae. The first is for absolute pressures and the second for gauge pressures with the additional correction for difference of temperature at entrance and exit. Both have been developed from natural gas practice and consequently contain the correction for specific gravity.

$$Q = 48.4\sqrt{\frac{d^5}{L}(P_1 + P_2)\ (P_1 - P_2)\frac{0.6}{g}}$$

$$Q = 48.4\sqrt{\frac{T_1}{T_2 T_0}}\sqrt{\frac{d^5}{L}(p_1 + p_2 + 30)\ (p_1 - p_2)\frac{0.6}{g}}$$

Prof. Unwin's Formula is given in the Gas World, June 11, 1904. The pressures are in feet of water and absolute; the diameter and length in feet; the coefficient of friction, c, is equal to $1 + \frac{1}{12d}$; Q is given in cubic feet per *second.*

$$Q = \frac{\pi P_1}{4P_2} D^2\ 468\sqrt{\frac{D}{cgl_f} \times \frac{P_1^2 - P_2^2}{P_1^2}}$$

Mackay's Formula. In his article on fans in gas works in the Journal of Gas Lighting for February 24, 1903, R. Gordon Mackay transformers Unwin's general formula, W being the weight of one cubic foot of gas.

$$Q = 1350\sqrt{\frac{d^5 h}{1.8 W l_f\left(1 + \frac{3.6}{d}\right)}}$$

He says that Pole's formula is probably more accurate.

Dr. Velde's Modified Pole's Formula, as given in "Journal fur Gasbeleuchtung," October 1, 1904, gives Q in cubic meters per hour, h in millimeters of water, 1 in metrs, and d in centimeters. The "Journal of Gas Lighting" gives the translation of this formula into English units as follows:

$$P_1 - P_2 = h = 393.7\left(\sqrt{1 + \frac{l\,g\,Q^2}{360,530,000\ d^5}} - 1\right)$$

Richards, in his book on "Compressed air" (1885) gives the following formula for the delivery of compressed air and applied to gas by introducing the factor g.

$$Q = 60\sqrt{\frac{10,000\ d^5\ c(P_1 - P_2)}{g\ l_f}}$$

A table is also given showing values of c corresponding to different values of d.

Hiscox gives a compressed-air transmission formula in his book on "Compressed Air" (1901) as follows:

$$Q = 60\,c\sqrt{\frac{d^5\,(p_1 - p_2)}{w\ l_f}}$$

Special tables are given to aid in the use of this formula also.

L. P. Lowe gives a high pressure gas distribution formula in his Pacific Coast Gas Association paper, see Progressive Age, October 1, 1904, which takes into consideration the effect of compression; 0.0761 is the weight of one cubic foot of air at 14.7 pounds atmospheric pressure.

$$Q = c\,\frac{p_2 + 14.7}{14.7}\sqrt{\frac{d^5\,(p_1 - p_2}{0.0761 g\, l_f\left(\frac{p_2 + 14.7}{14\ 7}\right)}}$$

c depends on d thus:

d =	0.5	2	3	4	5	6	7	8	9	10
c =	36.8	52.7	56.1	57.8	58.4	59.5	60.1	60.7	61.2	62.1

d =	14	16	18	20	22	24
c =	62.3	62.6	62.7	62.9	63.2	63.2

Pitot Tube determinations have also been used, especially on natural gas mains. The method is well described by W. B. Gregory, of New Orleans, before the American Society of Mechanical Engineers (see volume XXV of the Transactions.) F. H. Oliphant also describes it in his report on natural gas above noted. The formula of the Pitot tube as applied to gas measurement has been very carefully determined by Prof. S. W. Robinson, whose report is published in the Geological Survey of Ohio, volume VI, page 548. The final formula, calculated for gas of .06 specific gravity and a temperature of 50° F., is

$$Q = 1690\, d^2 \sqrt{h\left(1 + \frac{p}{15}\right)}$$

All the above formulae were derived from Dr. Pole's formula and are more or less successful attempts to add corrections for density and coefficients of friction due to compression. The more complicated formulae are simply attempts at greater refinement.

It has come to be pretty generally understood that each size pipe requires a change in the formula to give the particular results obtained. The coefficient of friction does not seem to vary with different densities of gas, but varies with each size pipe. Unwin says that the coefficient of friction varies with the roughness of pipe, diameter and velocity, and I would add possibly density.

I believe that the formulae recognizing a different coefficient for each size are the most accurate. I do not believe the full accuracy of any formula is yet established. Accurate results from actual tests should be kept by some one, and tabulated until a true formula can be secured. Until such time, practical working results can be had from the best natural gas practice as embodied in Prof. Robinson's formulae, and Cox's computer, also, which give safe results.

I have noted three records, the accuracy of measurement of which I do not know. At Newton, Mass., a 6-inch pipe line 9,600 feet long, 10 lbs. per square inch initial gauge pressure, 9.28 lbs. final gauge pressure, delivered 18,200 feet per hour.

At Chester, Pa., a six inch pipe line 7,514 feet long, 27 lbs.

initial gauge pressure, 25.5 lbs. final gauge pressure, delivered 20,100 cubic feet per hour. (Not satisfied with accuracy of measurement.)

Mr. Oliphant says he checked his formula on delivering natural gas 100 miles into a gas holder through 8 inch pipe.

Taking the Newton conditions and using the several formulae we obtained the following results:

Formula	Calculated Cu. Ft. per Hour.
(Actual volume delivered)	(18,200)
Pittsburg	18,380
Cox's	16,000
Oliphant's	16,260
" corrected	17,510
Robinson's	18,730
Unwin's	31,870
Velde's	22,060
Richard's (corrected for 0.6—g gas)	18,708
Hiscox's (corrected for 0.6—g gas)	16,250
Lowe's	26,910

I am indebted to Dr. H. B. Harrop for considerable assistance in obtaining several of the above formulae.

4. *Pumping Gas.* Only a few limiting conditions will be given, with a classification according to the services.

FOUL GAS.

With suction pressures in tenths of an inch water column and discharge pressure amounting to only a few inches, this is purely a rotary positive blower proposition. The vital points here are close governing to protect the hydraulic main seals, and machine construction such that there can be no fouling from tar. Higher speeds by fifty per cent. than heretofore used would insure better governing, while allowing for greater variation of output.

The cooler the gas is handled the less capacity will be necessary in the machine. Where the meter measurements are used to figure the required capacity of the exhauster, the volume at the pressure and temperature at the machine should

be calculated with allowance for shrinkage due to condensable matter dropped, and 10 per cent. for actual slip in the machine. Sufficiently close results may be obtained by using the formula :

$$v = \frac{17.64\ (h-a)}{460 + t}\ V$$

TRANSFER OF GAS FROM HOLDER TO HOLDER.

For pressures not exceeding eight or ten inches water column, a centrifugal blower may be used; for pressures over that the rotary positive blower will be more satisfactory. The constant speed machine is the correct application here, and close to maximum speed may be used unless a margin is specially desired. In large stations three machines, any two being of sufficient size for the work, should be used. This is especially true of gas engine outfits, for the economy of large and small units differing but little, sub-division in the above proportions is wise and not too costly.

TRUNK LINE WORK.

The conditions usually vary from 2 to 6 pounds; and high speed, high pressure rotary positive blowers are most suitable. Either constant or variable speed machines are permissible, the constant pressure machine seldom being necessary except as a protection against excessive pressure, due to stoppages of any kind. Here an automatic by-pass is ample protection; though a diaphragm regulator that can be changed readily is an advantage under certain cirumstances. Efficiencies vary from 75% to 92%, according to size and pressure.

TRANSMISSION LINES, 10 POUNDS AND UP.

The real problems of pumping gas begin here. Up to ten or twelve pounds the positive rotary gas pump should be considered. Simplicity, flexibility and first cost may be balanced against increased cost of attendance, valve complications and adiabatic efficiency. Above twelve pounds the field belongs to the reciprocating compressor, unless some unusual condition would justify compounding the rotary blower.

The balance of the problem is a question of fuel against cost of pipe; small pipes and high fuel account, large pipes and low fuel.

THE MECHANICAL ASPECT OF GAS DISTRIBUTION.

In the following revision of the material contributed to the Question Box of the Ohio Gas Light Association, "The Mechanical Aspect of Distribution" has been treated as viewed by the man who was either actually in charge or performing the work. In handling the subject the information gathered in the Ohio Question Box has been added to by information gathered from other sources wherever it seemed necessary to do so, care being taken to give the proper credit.

In case of a difference of opinion, where there was no preponderance of evidence in favor of either side, we have endeavored to present both sides, together with the argument, leaving the reader to decide.

The subject naturally divides itself into the consideration of mains, services, meters, and inside piping. The subject of mains may be further divided into low pressure and high pressure. In the consideration of the subject of low pressure mains, the question of the material used for the main is of the first importance, as the preparation for the work to be done must be made to conform to the best use of the material selected. Therefore we might further divide the subject of low pressure mains into cast iron mains, wrought iron or steel mains, and mains of miscellaneous materials.

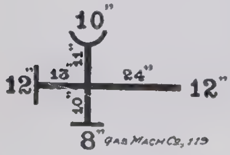
5. *Cast Iron Pipe.* Up to within the last few years, almost all of the low pressure gas mains were laid of the ordinary type of bell and spigot cast iron pipe. "This pipe has the advantage of not being easily corroded, and, barring electrolysis, it will last for at least fifty years in ordinary soil."—(D. McDonald, Western G. A.—1900.)

It might be thought that it would be advisable to order cast iron pipe for gas mains to be coated with either coal tar or asphaltum in the same manner as cast iron water pipe, and thus still further prevent corrosion. This is not the case, however, as the coating forms a thin film between the material

used for the joint and the pipe itself. In the course of time this film is dissolved by the action of the gas and the joint becomes leaky. In many cases, however, when it is suspected that there may be acid in the soil or the main subject to electrolysis, it would be advisable to coat the pipe as laid. This will be discussed in another section.

6. *Fittings for Cast-Iron Pipe.* In ordering fittings for the laying of a cast-iron line, it is advisable in nearly all cases to order the fittings with all hub ends, as this allows the short spigot pieces to be used which are cut from full lengths, and will also permit of uniform calking, as spigot fittings do not permit sufficient hammer room when the bell faces the fitting. It is also well to specify that the pipe and fittings shall be of the standard adopted by the American Gas Light Association, of which the table in the Appendix gives sizes and dimensions.

In case it is necessary these dimensions, also location of hub ends, spigot ends or flange ends, will be changed by the makers. For instance, if it were necessary a cross with one spigot end, one flange end and two hub ends could be procured. When ordering fittings, and especially crosses and tees or fittings having a special arrangement of openings, it is well to send a sketch of the fitting. In designating sizes, the run of the fitting is given first, and then the size of the branches. If necessary, the length of the run and branches should next be given, followed by the style of openings, thus:

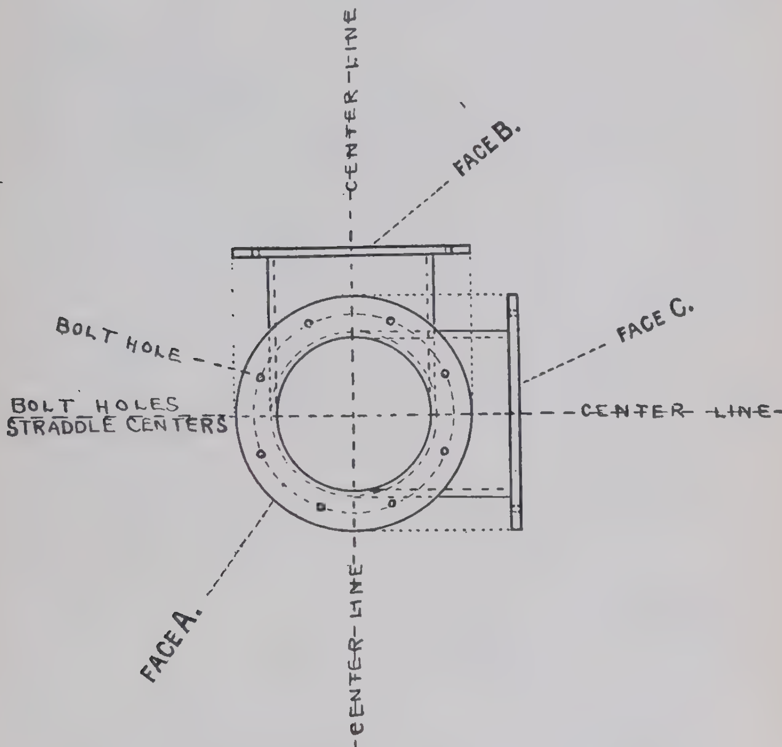


One Cross 12" x 12" x 10" x 8"
Length 13" x 24" x 11" x 10"
Flange x Spigot x Hub x Flange.
Or to avoid errors send us a sketch of same.

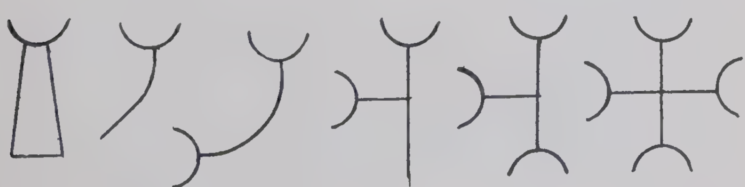
In ordering flange fittings the diameter of the flange should be given, also bolt circle and the size and number of bolts—also note if the bolt holes are straddle or on center lines. By center lines is meant a line drawn across the face of a flange through the center in the same plane as the axial line of the side branch if there be any.

In case of side branch tees and crosses, the center line will

be in the plane of the axis of one branch and at right angles to that of the other from which it follows that the center line, on opposite flanges must be parallel and opposite, for if they are not, a twist in the pipe will be the result.



The cut below will give an idea of the sketches which should be sent to explain orders for fittings.



Lack of preparation often causes delay and adds to the cost of the work. It will always be advantageous to have an excess of fittings on hand to guard against delay when unexpected obstructions are encountered. This is absolutely necessary in city work, and 30, 60 and 45 degree bends are always a good thing to have around.

7. *Tools for Laying Cast Iron Pipe.* After the material, including pipe and fittings, yarn, cement, or lead, has been ordered, it would be well to see if we have all the tools needed for the work. The number of laborers required and the tools needed will, of course, vary with the size and length of the main to be laid. If you are going to lay considerable main, say 4, 6, or 12 inch, fifty laborers, two pipe handlers in trench, one yarner, four calkers, one lead joiner, and one blocking man will be sufficient to start your laborers—(O. G. L., 1902, John Franklin.)

The following list of tools will be found approximately correct for equipping a gang of this size:

1 tapping machine, ¾″ to 2″ taps.
4 calking hammers.
2 trimo wrenches, 18″ and 24″.
4 8-pound striking hammers for use with dog chisel in cutting cast iron pipe.
2 15″ monkey wrenches.
3 dog chisels with handles.
1 2-pound machinist hammer.
1 12-pound sledge hammer.
2 paving hammers.
4 sets calking tools—8 pieces to the set.
6 lead chisels.
4 split chisels.
4 yarning irons.
6 cold chisels.
6 diamond points.
2 5-ft. crowbars.
10 railroad tamping bars.
6 4″ trowels.
1 10″ trowel.

2 18″ spirit levels.
1 iron oil can.
1 handsaw.
1 2-man saw.
2 axes.
2 dozen street lanterns with red globes.
1 dozen iron plug dirt pounders.
1 5-gallon kerosene oil can.
1 15 x 30 galvanized iron cement can.
1 100-foot metallic tape measure.
1 12-foot pipe scraper for scraping dirt out of pipe.
1 wheel barrow.
4 street brooms.
1 salamander furnace with lead kettle for same.
2 small lead kettles for pouring joints.
2 pieces Manila rope 30 feet long.
1 tripod or A-derrick.
1 Yale and Town chain block, or similar make.
4 tunneling shovels.
90 railroad picks.
40 pick handles.
60 sharp nose D-handle shovels.
10 flat nose D-handle shovels for bottom work and street cleaning.
1 lot assorted gas bags. These should never be left around in the tool box, but should be called for as needed.
6 12 x 18 x 4″ galvanized iron cement pans.
4 galvanized iron water buckets.
4 pair rubber gloves.
Wooden plugs or stoppers to fit various size mains.
2 tool boxes—1 for lighter material and 1 for picks, shovels, crow bars, sledges, etc.
1 or more three wheel pipe cutters to cut from ¾″ to 2″.
1 threading machine ¾″ to 2″.
2 slings of rope.

8. *Unloading Pipe.* When the pipe arrives the smaller sizes up to six inches in diameter may be unloaded from the car by the men simply lifting them and transferring them to

the wagon, but in sizes 6 inches and larger it is usually found advisable to unload by having a piece of ¾" Manila rope about fifty feet long, one end of which is attached to a stake on the car; one turn is then taken around the pipe to be unloaded, and by paying out the rope the pipe is allowed to roll from the car into the wagon over 2 x 12 inch skids provided for that purpose. In sizes of 10-inch and larger, it will be found advisable to either unload with a derrick or to use two pieces of rope, one at each end of the pipe in the same manner as is used on the six-inch pipe. When the pipe is hauled to the street on which it is to be used it should be unloaded from the wagon on the opposite side of the ditch from that on which it is proposed to throw the dirt when the trench is to be dug. In some places it seems customary in digging the ditch to throw the dirt toward the curb, in this case the pipe should be lined up on the opposite side of the street, but in a place where it is proposed to throw the dirt from the ditch toward the center of the street the pipe should be unloaded on the same side of the street as that on which the trench is to be dug. This permits the pipe to be moved around and placed in the trench without carrying it over the dirt. "Where possible, the pipe should be unloaded with the hub end pointing the same way in which the pipe is to be laid."—(John Franklin, O. G. L. A.— 1902.) This will avoid considerable labor in turning the pipe when the work is begun. Carrying of the pipe will be lessened if the pipe be strung end to end in about the same position as that in which it will lay in the ditch, leaving sufficient extra lengths at each intersecting street to make the crossing.

9. *Lead and Hemp.* If the pipe is to be laid with lead joints, a sufficient quantity of lead and hemp must be provided. The amount depends a great deal on the relative depth of hemp and lead in the joint and also on the width of the joint space. The following table gives an approximate idea of the amount of lead required:

Size of Pipe	Depth	Thickness	Weight Lead Pounds		Weight Yarn Ounces
3″	1½″	⅜″	3		
4″	1½″	⅜″	3½ to	5	3¼
6″	1½″	⅜″	5	6	4¾
8″	1¾″	⅜″	7	8	5¾
10″	1¾″	7–16″	9	12	6½
12″	1¾″	7–16″	13	16	10
16″	2″	7–16″	17	25	12
20″	2¼″	7–16″	21	37½	14½
24″	2¼″	½″	24	50	21½
30″	2½″	½″	30	65	22

The larger amount of lead, given in the table, is the nearer correct amount.

It is impossible to give an exact amount of hemp or oakum required as the percentage of tar in the oakum greatly affects its weight.

10. *Digging the Trench.* If the material is all on the ground or has been provided for, the laborers may be taken to the work. One or two men should go ahead to line up the trench. If the gang consists of more than fifteen men, it will be found advisable to have two foremen, one to look after the diggers and the other the pipe layers. If the gang is a larger one, three foremen may be used to advantage, one having general charge of the work and the pipe layers, one sub-foreman over the diggers, and another over the back fillers. This division of labor will insure closer inspection and better work.

For 4″ pipe, 6″ and 8″ the trench should be made from 25″ to 30″ in width.

For larger mains, the width of trench will be increased proportionately.

After the trench has been lined up, the laborers are put to work, the trench laborers being placed from nine to twelve feet apart, according to the kind of soil, the number of men and the amount of trench allowed open. As the liability to accident is increased by the amount of trench left open, this should be as small as is consistent with good work.—(John Hellen, Michigan Gas Association, '04.)

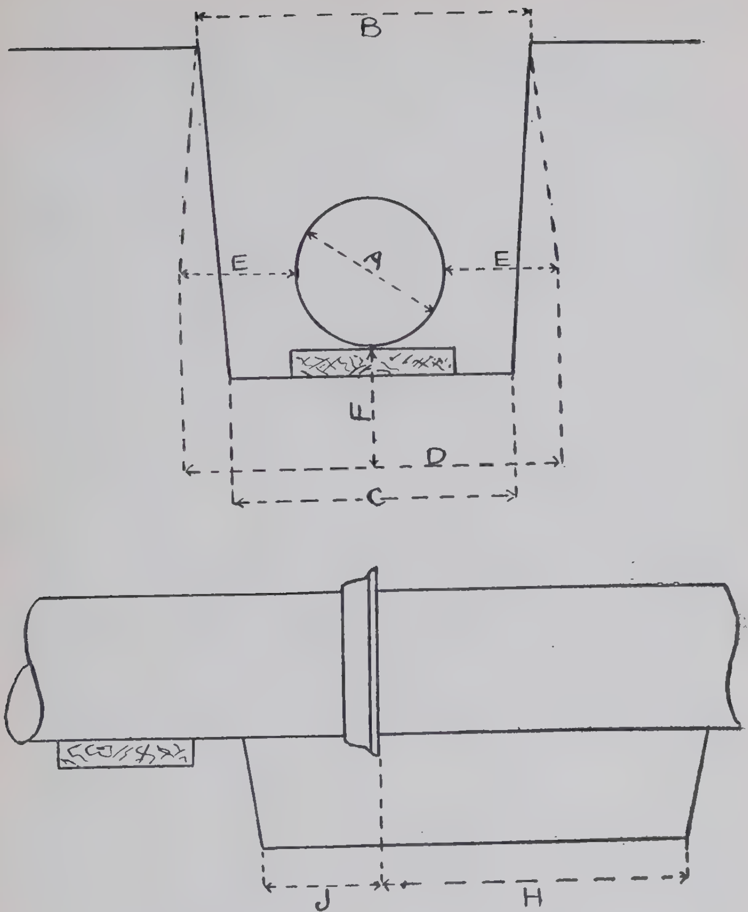
After the laborer has completed the section assigned to him, he is moved forward to the front of the gang. This method of working always insures that each laborer will do his share of the work, and all of them will work nearly as well as the best man you have.

11. *Depth of Main.* The trench should be dug to approximately the depth at which the main is to be laid, and no fixed rule can be prescribed for the depth at which mains should be laid. In a general way it is governed by these conditions: The question of getting below the frost line, the matter of avoiding obstructions and the question of securing sufficient pitch for draining. In addition to these, the mains should also be laid deep enough to avoid any trouble caused by the jar of traffic on the street. (Frank Hellen, Shelton, Simpson, '04, Q. B., No. 105.)

The first three conditions are purely local, but the frost line has been given as 5 feet deep for 30 degrees below zero. (Ohio Q. B., 1906.)

"In order to be below the jar of traffic, the pipe should be laid to cover at least three feet deep in large cities where there

Size of Pipe A	B	C	D	E	F	H	J
3"	22"	22"	22"	8"	8"	18"	6"
4"	22"	22"	22"	8"	8"	18"	8"
6"	22"	22"	24"	8"	8"	20"	8"
8"	24"	22"	26	8"	8"	20"	10"
10"	26"	22"	28"	8"	10"	20"	10"
12"	28"	24"	32"	10"	10"	26"	10"
16"	32"	28"	42"	14"	12"	32"	10"
20"	36"	32"	58"	18"	12"	36"	12"
24"	44"	36"	66"	20"	12"	38"	12"



A - Size of pipe
B - width of top of trench
C - width of bottom of trench
D - width of bell hole
E - clearance at side
F - clearance at bottom
H - calking space
J - bell clearance

Depth and Width of Trench.

is heavy traffic, and thirty inches in the smaller towns. (Simpson and Walton Forstall.—O. Q. B.—'04—No. 105.)

For difference in opinion and some estimates, see original reference.

12. *Grade of Mains.* In the laying of street mains it is of the utmost importance to see that all pipes are on a slight incline or gradient, so as to drain all condensation to a given point which is situated at the lowest part of the main, where all the condensation is collected by the means of drip wells. If the pipes were not laid on a perfect gradient there would be a collection of water in the various parts of the pipes where sags or traps occurred, which would hinder or stop the flow of gas, according to the depth of the trap and the amount of water therein.

The concensus of opinion appears to be that 2 inches in each 100 feet is the minimum permissible grade for main lines, and that services should have at least 6 inches in 100 feet. In case the minimum grade is used, great care should be taken in laying the pipe. It is also observed that a lesser grade can be used when the flow of gas and condensation are in the same direction than would otherwise be advisable. Large mains can also be given a less grade than smaller ones. For variations and a number of individual opinions, see original references. ('03—Q. B., No. 110 and '04—Q. B., No. 120.)

In streets where the ground has sufficient fall it is comparatively easy to lay gas mains to grade. The only point to be looked out for being to see that the grade of the main is continuous, and that there are no sags or hollow places, except where it is intended to place a drip to catch the condensation. On this work an ordinary level may be used; sometimes it is sufficient to put the level on each length of the pipe, look at the level and see that the pipe has a fall in the right direction. It is sometimes advisable to have a straight edge 12 feet long, or one that will reach from one bell to another. At one end, on the under side of this straight edge, a block is fastened of the thickness that it is expected the main will have fall for each length. The straight edge is placed upon the pipe with the end to which the block is attached in the direction in which the main falls; the spirit level is then placed on top of the

straight edge, and when it shows level the pipe will have the amount of fall called for by the thickness of the block.

In laying street mains or services, especially where obstruction exists on the proposed line, the use of three T-pieces, of which a description follows, has been found of great convenience in readily obtaining the line of uniform fall. The tees are of wood, the cross pieces being made all the same size, and set square with the uprights. Two of the latter are just equal length, but the third one is longer by an equal distance to the thickness of the cross-piece.

From four to five feet is a handy length for the uprights. In using them, the two equal tees are set vertically, one at each end of the line, their feet resting in the ditch at the depth desired for a bottom. To find the line for the bottom at any point between these, hold the other tee vertically in the ditch at the place in question, and deepen the trench, following it with the tee until, sighting across the top of that at one end, the middle one just cuts off the light between its under side and the top of the one at the opposite end. Trenching work may thus be carried on past mortar and brick piles, intersecting streets, railway crossings, rock bottoms, or any temporary obstruction, with confidence in the certainty of being able to join the trenches later, and have all continuous. Whether working with or without instruments, the T-piece will be found valuable.—Wrinkle Dept., Western Gas Association—1893.

Where the ground is very level or it is very hard to determine grade, an engineer's or a surveyor's level should be used. A preliminary survey of the street should be made to determine in which way the main is to fall and where the drips could be placed to the best advantage. The City Engineer should also be consulted. After this is done, and the grade to which the pipe should be laid is determined, 2 x 4 stakes, cut of the required length, can be placed on each side of the trench. These stakes may be driven, if deemed advisable, after the trench has been lined up and before it has been dug. On these stakes is marked a grade which is a given height above the top of the pipe. If the pipe should be covered 3 ft., it is advisable, for instance, to mark the grade on the stakes,

4 ft. 6 inches above the top of the pipe. This will allow the cross bars to be about 18 inches above the surface of the ground. Cross bars made of 1 x 4 material are then nailed acoss the trench from one stake to another. The top of the cross bar being on the grade lines marked on the stake, each pair of stakes being 50 feet apart along the trench. A line is then stretched from one cross bar to the other. The ditch may now be bottomed up and the pipe laid at a uniform grade by measuring down from this line to either the bottom of the ditch or the top of the pipe, as the case might require. It will help the work somewhat if the line is not stretched until

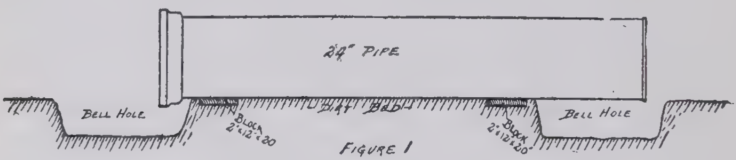


FIGURE 1

CORRECT PIPE BEDDING — BLOCKING COUNTERSUNK.

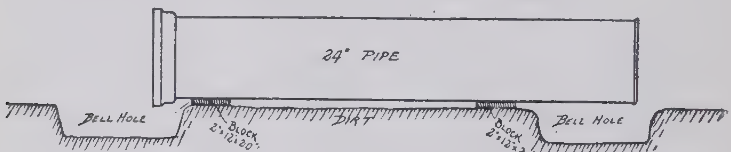


FIGURE 2

INCORRECT PIPE BEDDING — BLOCKING ON TOP OF DIRT

HOW MAINS SHOULD BE BEDDED.

the ditch is dug approximately the required depth. Some authorities advocate the digging of the ditch a trifle deeper, and then the pipe should be graded by being placed on a bed block. In this case it is considered preferable to use wooden blocks instead of either brick or stone, as the wood would be slightly elastic and would be apt to give a little under any stress that would be likely to come on the pipe. (O. Q. B.—No. 513 and No. 492—'06.)

After the ditch has been properly bottomed, a hollow space should be dug in the bottom of the ditch for the reception of the bell of each length of pipe. In soft ground the preliminary bell holes may be made comparatively small, and when the

pipe layer has the pipe in position, he can, with a shovel, very rapidly dig the hole larger in front of the bell, throwing the dirt back on the pipe to help hold the pipe in position. In hard ground, or in rock, however, this makes the pipe laying too slow, and it is advisable in that case to measure exactly where the bell holes will come and have them dug out full size before the pipe is laid in the ditch. The bell holes should be liberal in size to insure that the calker will work rapidly and do the work well. It is also well to carefully examine and test the pipe with a hammer, so that no defective or cracked pieces are used. The test should be made while the pipe is on skids or blocks. Pipes 4 inches in diameter may be handed directly to the pipe layer in the ditch. 6, 8, 10-inch and 12-inch pipe should be lowered into the ditch by means of a rope passed around the pipe somewhat in the same manner as it was unloaded out of the car, and where there is a good clay bottom, 16-inch pipe can be handled the same way without fear of breakage. These ropes can then be used by the men on top of the ditch for lifting the pipe when in the ditch and placing it in position.

If the ropes are crossed, that is if the men on top of the ditch each lift with the rope from the opposite side of the pipe, there is less liability of knocking loose dirt and stones into the ditch.

For the handling and lowering of heavy pipe and fittings into a trench, a tripod is sometimes used, the legs of the tripod resting on planks properly braced to prevent slipping, and a block and tackle rigged to lift the pipe. "Sometimes the legs of the tripod or derrick may be on wheels running on heavy timbers placed on each side of the trench" (Franklin, —'03—Q. B., No. 134.)

"A convenient form of derrick is four-legged, with a traveler running on an overhead beam across trench."—(Shattuck, A. G. L. J., No. 11 and 14—'98.)

Another method suggested is a "single gin-pole, guyed at the top with four guys employed as a support, and for lifting, suspend a pair of three sheave blocks from the top, running a fall line through a snatch block, secured at the bottom of the pole with chain and then to a capstan set at a safe distance

and operated with a team of horses. This outfit can be rigged to lift any weight, and if the guys from the top are fastened to anchorages with tackle, it can be inclined to any reasonable angle." (Q. B., No. 131, Perkins.)

It is suggested that "this work is a question of personal safety to employees rather than quickness, and that the trench should be properly braced and all precautions taken to avoid caving. In case of very wide ditches, lower pipe on an incline formed of timbers of sufficient strength and using a rope fastened to a stake, then wrapped once around pipe under side and then around another stake driven in bank. Lower pipe by playing out rope around stake. When pipe is at bottom of ditch, use a small tripod and triple lifting block for placing in position." (Frank Hellen—'03—Q. B., No. 131.)

A tripod or a derrick with good chain block (not a differential), will give the most satisfactory results.

13. *Jointing Pipes With Lead.* When the pipe is placed in the ditch the spigot end of one length is inserted in the bell end of the other and the length driven home, care being taken that inside of bell and end of spigot are clean. It is customary to use one of the pieces of yarn to lift the spigot end as it is inserted into the bell end of the pipe previously laid. This assists in keeping the spigot central in the bell, and avoids somewhat the necessity of wedging it up after it is in place. It will be found advantageous in using a derrick to have the sling far enough ahead to make the pull of the chain on the rope assist in getting the pipe home. The length which is being laid is then driven home, lined up and fixed in place by the tamping of a little dirt around the middle of it. After this is done the yarn which had previously been inserted into the bottom of the joint space is driven solidly into place by means of a calking hammer and yarning iron. A sufficient number of strands of packing are taken to form a rope of a diameter a trifle larger when twisted tight than the width of the joint space, and this is cut into lengths sufficient to make the circumference of the pipe and having the ends lap a little. These pieces are inserted into the joint space, one at a time, care being taken that the laps do not all come at the same point in the circumference of the pipe and each piece is driven

home separately by means of a calking hammer and packing iron, being careful to always begin to drive at the bottom of the pipe and work toward the top, as there is always a tendency for the pipe to settle and make the bottom space smaller than the upper one.

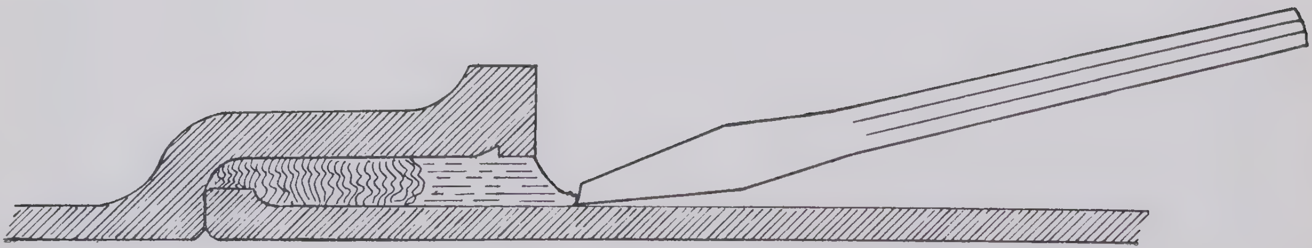
The packing is driven home tight, a sufficient number of pieces being used to fill the joint space to the required depth, leaving, usually about 1½ inches for the lead.

A clay roll, or one of the patented appliances used as a dam for making lead joints is now put around the pipe close to the hub end so as to leave a triangular space just in front of the hub and next to the pipe proper and a gate or opening is left on top of the pipe. Care should be taken that no excess moisture or water is in the bell, as serious results may occur when the joint is poured. The lead is poured into this gate or opening and fills the triangular space as well as the joint. To flow well, the lead should be hot enough to scorch a piece of dry paper dropped into it. If too hot it will burn the yarn. A little lard oil, tallow, or resin placed in the gate of the joint when the lead is being poured will help the lead to flow smoothly and prevent "blowing out" by reason of dampness in the joint. (Walton Forstall, A. G. L. A., 11—14—'98.) (Franklin, O. G. L. A., 1902.)

When the lead has hardened, the joint runner is removed and the lump of lead where the opening for pouring was made is cut off, leaving a sufficient amount to drive back so as to make the joint uniform throughout.

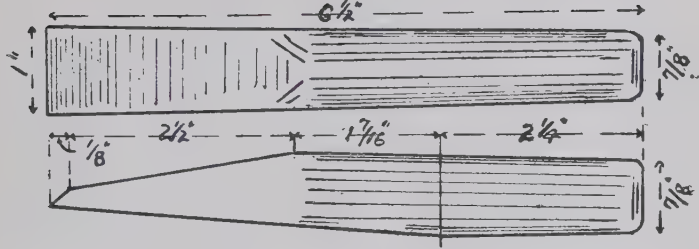
The lead is then driven back with a driving chisel or blunt cold chisel the chisel being held close to the pipe so that the lead will be turned back forming a shoulder for the first calking tool to drive against. The first calking tool which is about 3-16 of an inch thick is now used. After being driven back throughout the whole circumference of the pipe with this tool, larger tools are used successively until the full width of the joint has been reached. The work with each tool being begun at the bottom of the pipe and carried around each way, finishing at the top.

The thickness of the last tool used should not be greater than the width of the joint. In order to have the tools fit

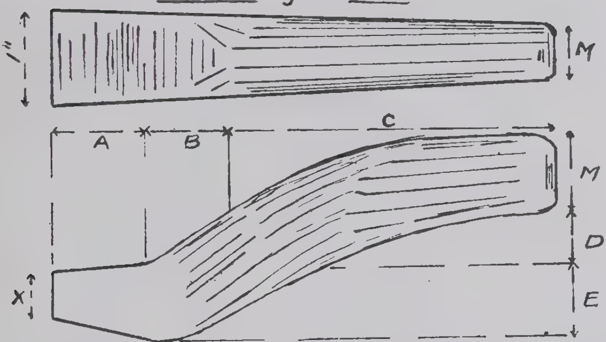


Using First Tool on the Lead Joint.

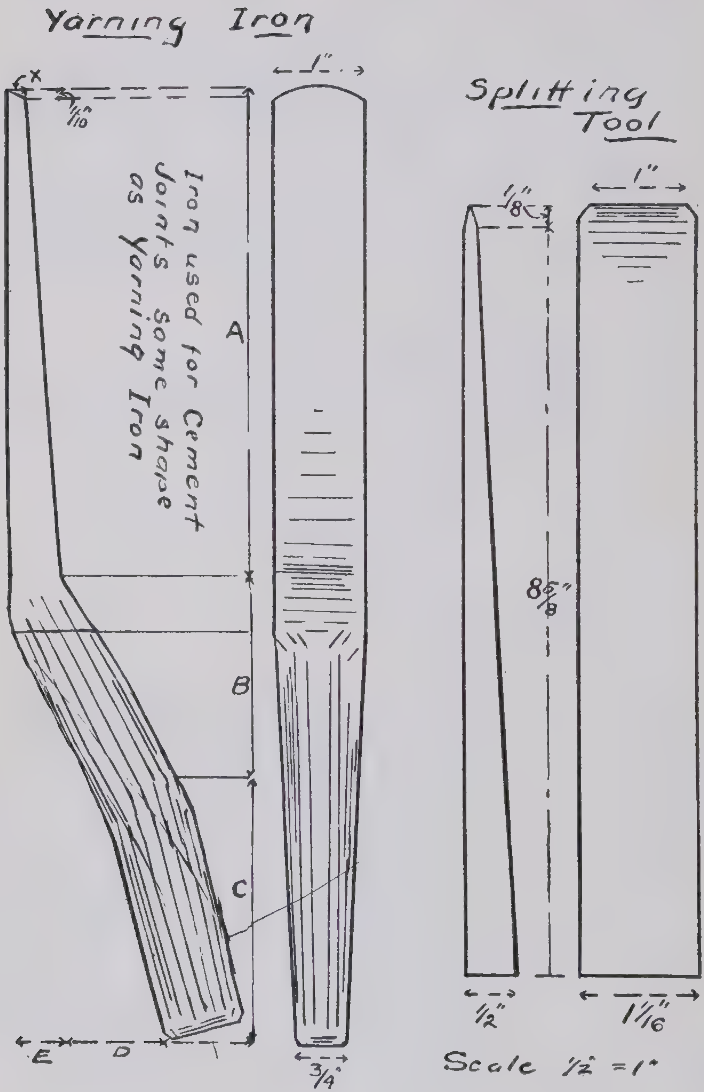
Lead Chisel



Caulking Tool



Name of Tool	X	A	B	C	D	E	M
Yarning Iron	1/8"	5"	1½"	3½"	1"	½"	1"
Cement Iron	5/16"	2½"	1"	4½"	1¼"	½"	7/8"
Caulking Tools	1/4"	1"	1"	5"	1¼"	½"	7/8"
" "	5/16"	1"	1"	5"	1¼"	½"	7/8"
" "	3/8"	7/8"	7/8"	4"	1¼"	5/8"	7/8"
" "	7/16"	7/8"	7/8"	4"	1¼"	5/8"	7/8"
" "	½"	7/8"	7/8"	4"	1¼"	5/8"	7/8"
" "	9/16"	7/8"	7/8"	4"	1¼"	5/8	7/8"
" "	5/8"	7/8"	7/8"	4"	1¼"	5/8"	7/8"



Yarning Iron
1"
1/10"
Iron used for Cement Joints same shape as Yarning Iron
A
B
C
E
D
3/4"
Splitting Tool
1/8"
1"
8 5/8"
1/2"
1 1/16"
Scale 1/2" = 1"

the joint exactly, it is well to have them in sizes varying in thickness by 1-16 of an inch.

When calking the joint, care should be taken that the tool is held in the proper position and close to the pipe being calked, and also that the calking is done uniformly all around the joint. It is a good idea to have the calker mark his initial on a joint so that in case of leakage the responsibility can be fixed. This makes the men more careful.

14. *Lead vs. Cement Joints.* There has been much discussion regarding the material which is best to use for making joints in cast iron gas pipe. Lead joints exclusively, cement joints exclusively, and alternate cement and lead joints being advocated. The idea of using combined lead and cement is that the lead joint would allow for the contraction and expansion of the pipe. One lead joint may be used to 5 or 8 cement ones. (See original argument, '04, Q. B. Nos. 107 and 108.) A lead joint undoubtedly allows for a certain amount of expansion and contraction and will also stand some vibration and displacement and, if properly made, can be made tight. On the other hand, it is more subject to leakage under the action of electrolysis than is a cement joint. A cement joint is absolutely rigid and does not allow for contraction and expansion, but experiments seem to indicate that the expansion and contraction is either not as great as is generally supposed, or else is taken up by molecular action within the pipe itself. A line laid with lead joints might be apt to have a number of small leaks. A line laid with cement joints, if it leaked at all, would be likely to leak through a fracture of the pipe. "It seems to be believed that cement joints can be made at one-fourth the cost of lead, that they can be made absolutely tight, and, if properly made, are satisfactory." (Walton Forstall,—'04—Q. B., No. 107.)

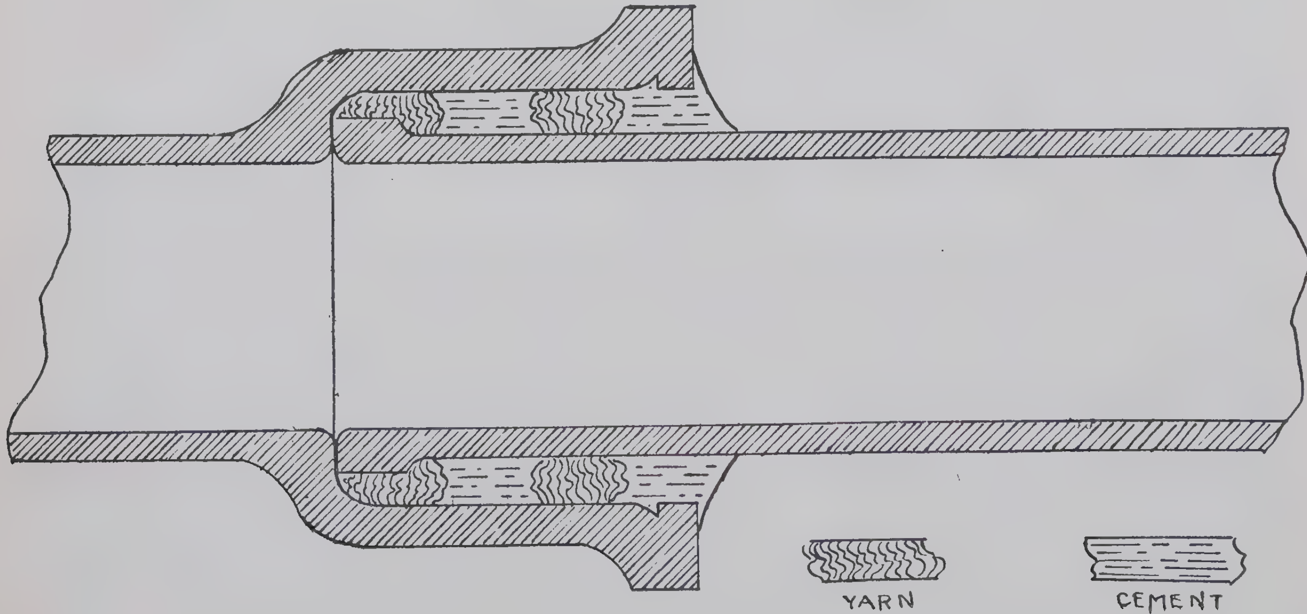
15. *Making Cement Joints.* The preparation for the laying of a line with cement joints is about the same as that for lead joints, with the exception of the material ordered. The cement should be of the best quality and of a brand which is slow setting and which does not either shrink or expand in setting.

A test of cement for this work is made as follows: A quart bottle is filled with a grout composed of some of the cement to be tested, mixed up thinly with water; this is placed aside and allowed to set. If the cement expands very much in setting, it will break the bottle, and the amount of its expansion can be seen by the greatness of the fracture. There is some discussion as to whether tarred or untarred yarn should be used in making cement joints, but the preference appears to be for the untarred yarn, for while tarred yarn will drive tighter, it is practically impossible to get tarred yarn containing a minimum amount of tar, and the oil coming from the tarred yarn prevents the cement, with which it comes in immediate contact, from setting. (See argument.—'06—Q. B., No. 484.)

Table of cement and yarn required as prepared by von Maur, W. G. A., '05:

Size of Pipe	Cement in Quarts	Cement in Pounds	Water in Pints	Yarn in Ounces
4″	1 to 1½	2.25 to 4.10	4/5 to 1 1/3	4
6″	1½ to 2	4.10 to 5.50	1¼ to 1⅝	6
8″	2 to 2½	5.50 to 6.87	1¼ to 1½	8
10″	2½ to 5	6.87 to 8.25	1½ to 2	10
12″	3 to 4	8.25 to 11	2 to 2½	12
16″	4 to 5	11 to 13¾	2¼ to 2½	15
20″	5 to 6	13¾ to 16½	2½ to 3½	20
24″	8 to 8½	20 to 23	5 to 5½	27
30″	7 to 7½	19 to 21	4 to 4½	27

After the spigot end of the pipe has been entered into the bell in the same manner as that for making a lead joint, if the pipe has been in the hot sun prior to making the cement joint, it will be well to cool it by pouring water on it, otherwise the contraction of the spigot will cause it to draw away from the finished cement joint, and the contraction of the bell has a tendency to crush it. The first piece of yarn having been driven home tight, a second piece of yarn of sufficient length to completely encircle the pipe is driven into the joint space. In the meantime the pipe has been thoroughly bedded by tamping earth around the pipe between the joints, so that there can be no vibration or moving of the pipe. The cement



Finished Cement Joint.

is now mixed up, no sand being used and no cement being mixed more than five minutes previous to the making of the joint. The cement, when mixed, should be of the consistency of stiff putty, and is forced into the joint with the hands, a pair of rubber gloves being worn by the workman to protect his hands from the action of the cement. A packing stick with a blunt end will be found useful in driving back the cement. A second strand of yarn is now driven in on top of the cement and sent up tight. The joint is again filled with cement, and the third strand of yarn is driven against that. This is continued until the joint is full, after which it is finished off.

In some cases it is considered advisable to soak the yarn used in cement grout, wringing it out thoroughly so as to leave as little moisture in the yarn as possible. It is advisable in all cases to have the yarn moist or damp, but not wet. It is as important that the yarn in a cement joint be driven tightly as it is for the lead in a lead joint. (O. Q. B., No. 484—'06.—No. 491.—'06.)

Care must be taken that the pipe is not jarred or moved in any way after the joint is made and before it is thoroughly set. For this reason no dirt should be tamped around the pipe after the joint is made and before it is set, nor should the joint makers follow the pipe layers too closely, for if they do the shock of the spigot end of the pipe when entering the bell end and being sent home will be transmitted along the line and will make the joint crack while setting. In hot weather the joint should be covered to protect it from the rays of the sun and prevent it from drying out too quickly. A piece of wet burlap is an admirable thing for that purpose. In cold weather the joint may be made by mixing the cement with warm water. It must be noted, however, that in order to have a good joint, the cement must set before being frozen. (For extended discussion on Cement Joints see "Cement Joints," by Jacob D. von Maur—Western Gas Assn., '05.)

For an extended discussion on the kind and size of fittings to be used in making connections to various size mains, reference is made to notes on mains and main laying by Walton Forstall, A. G. L. A.—'98.

In this paper Mr. Forstall advocates the following table to determine the size of connections and the method of making same.

NEW MAINS TO EXISTING MAINS.

Size of New Mains	Size of Existing Mains							
	30 in.	24 in.	20 in.	16 in.	12 in.	8 in.	6 in.	4 in.
4 inch	Saddle Piece or Hat Flg.	Saddle Piece	Saddle Pce.	Insert Branch	Insert Branch	Insert Branch	Insert Branch	Insert Branch
6 inch	"	"	Split Sleeves	"	"	"	"	
8 inch	"	"	"	"	"	"		
12 inch	Insert Br'ch	Insert Branch	Insert Branch	"	"			
16 inch	"	"	"	"				
20 inch	"	"	"					
24 inch	"	"						
30 inch	"							

For drawings and table of dimensions of Hat Flanges and Hub Sleeves, see Appendix at end of paper.

In connecting mains to mains the idea is to use a saddle piece, otherwise called a hat flange, wherever the disparity between the two mains is very great, and the largest so large that a split sleeve with hub cast on would involve heavy cost. As the disparity and the size of the largest main decreases split sleeves are used, and in turn ordinary branches.

16. *Cutting Cast Iron Pipe.* In cutting cast iron pipe, the pipe should first be marked around the circumference where the cut is to be made. On the larger size pipes an easy way to make the mark so that the pipe will be cut off squarely is to have a piece of sheet metal, card board or heavy paper from 5″ to 18″ wide and long enough to more than make the circumference of the pipe. This is wrapped around the pipe closely, and the mark for the cut is made at the edge of the cardboard. It may then be cut, using a dog or striking chisel and a sledge hammer. The first cut around the whole circumference of the pipe should be a very light one. This cut should be followed by others around the circumference successively, care being taken that the cut is kept of a uniform depth around the whole circumference of the pipe. As a preventive of cracking some authorities deem it advisable to use a diamond

point chisel to make the first cut, and still others on larger sizes use a diamond point in making the first cut both on the inside and the outside of the pipe. (Simson, Frank Hellen, Franklin.—'03—Q. B., No. 133.)

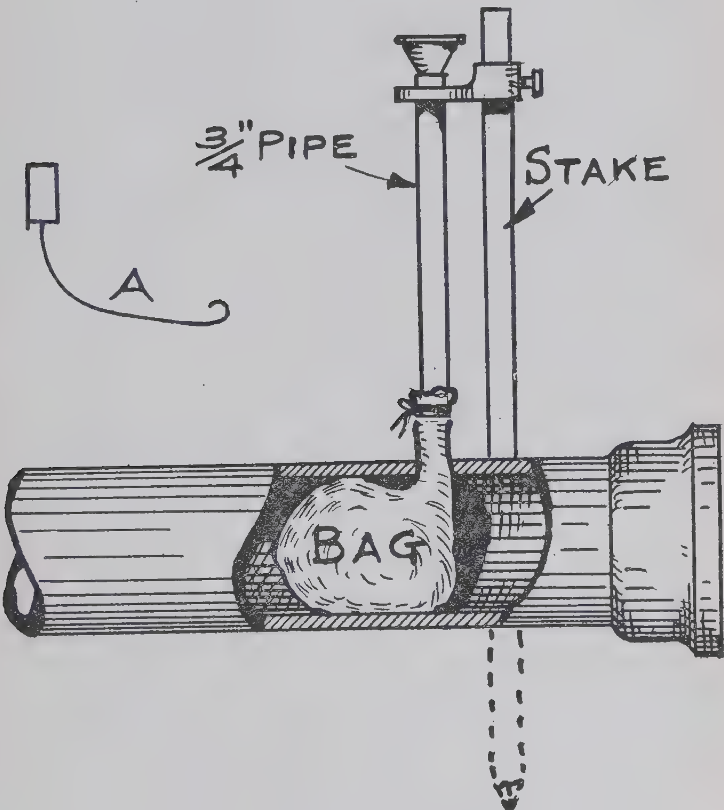
It seems to be conceded that in making extensions of present mains, the safest way is to leave the connection with the live line until the last. (Ohio Gas Light Assn.—'02—Franklin.)

17. *Gas Main Bags.* Originally beef bladders were inflated and used for shutting off the flow of gas in mains while connections were being made, but the difficulty in procuring these in a condition to be used led to the substitution of rubber gas bags. There are now a number of patented appliances for this purpose on the market, but the rubber bag is the most universally used. The hole for the insertion of the gas bag should be drilled or cut large enough so that the bag may be inserted into the main without crowding. After the hole is drilled care should be taken to push all cuttings away from where the bag is to be placed so as not to cut the bag. A swab of waste on a stick will accomplish this. A little hard soap may be used to fill up the threads and prevent them from cutting the bag, or, better still, a thin brass spun ferrule of the proper size is placed in the hole and the bag is slipped through the ferrule. A piece of thin sheet gum with a hole through the center slipped over the stem of the bag will aid in making tight. The bag should always be tested and examined before being inserted, and it may be remarked that as much depends upon the proper placing and insertion of the bag as upon how hard it is blown up.

In case any difficulty is experienced in blowing up a bag, it is suggested that a bicycle pump be used for this purpose, care being taken not to force the gas bag too hard. Where there is a very strong flow of gas in the main, it is sometimes found advisable to insert a fork made of heavy wire in front of the gas bag to prevent it from slipping along the main, the prongs of the fork passing on each side of the stem of the bag. In bagging open ends it will be found advisable to use two bags, one in front of the other, so that in case of the failure of one bag, the other will remain tight. When inserting a bag, always have extra help on the ditch to assist the men in the

ditch in case of necessity. Oil or condensation on the bottom of the main has a very deteriorating effect on the rubber used in making gas bags, and they should be wiped clean after being removed from the main.

There is now a canvas covering made which protects the bag. (Q. B.—'05—No. 581.)



Cloth Gas Bag.

When the bags are stored away, they should be washed with lukewarm water, inflated almost full, rubbed with pure tallow and stored in a cool damp place. (McAdam, Shaw.—O. Q. B.—'05—No. 627.)

It seems to be conceded that there is no way of reviving the

rubber in a bag after it has once deteriorated. (O. Q. B.—'05 —No. 628.)

At least it would be unsafe to use gas bags which were in this condition.

There is also a canvas or cloth bag.

The illustration represents a gas bag which has been used for a number of years. The bag is made from cloth usually used for bed sheeting, and cut in the shape described in the enclosed sketch. The bag is cut about 1½" larger than the circumference of the pipe, sewed and turned inside out, and dipped in linseed oil to make it hold water. The bag is placed over the hook (A) and put into the pipe, after which the hook is removed and the ¾" pipe is fastened to the mouth of the bag. Water is poured into the pipe, and fills the bag and stops the flow of gas. The pipe is supported by a stake, which keeps it in position. To remove the bag, place hand at the mouth and pull out the pipe. Pull slowly on the bag, which will force the bag to the inner or top surface of the pipe and cause the water to rush out in a few seconds. From 2 to 3 lbs. can be created on the bag, depending on the height of the water column, fifteen seconds being necessary to insert the bag and cut off the flow of gas. A 10" bag will bag-off a 10" and 8" pipe. A 6" bag will bag-off a 6" and 4" pipe. A 4" bag will bag-off a 4" to 3" and 2" pipe.

WROUGHT IRON LOW PRESSURE MAINS.

In laying wrought iron mains, the preparation to be made is the same as for cast iron mains, with the exception that it is not customary in laying low pressure natural gas mains to make any provision for taking care of condensation. Consequently, low pressure natural gas mains are not laid to grade. There is, of course, some difference in the tools required for the work. In addition to the ordinary tools required by the laborers for digging the trench, etc., the following tools will be needed by the pipe layers.

18. *Tools.* Swabs for cleaning out the different size mains.
2 pipe jacks and boards.
4 pair of tongs for each size main to be laid.

2 set of chain tongs.
Diamond point chisels.
Cape chisels.
Machinists' hammers.
Crowbars.

The lay tongs are pipe tongs made on purpose for this kind of work.

They have very long handles, are made heavy, and the bit is slipped in place and held by a wedge. The bit has four sides, and when one becomes dull the wedge is driven out and the bit turned so as to give a fresh edge for biting the pipe. The chain tongs are used on the fittings.

19. *Dopes Used.* In addition to the tools some dope for use on the threads is required. In natural gas work a black asphalt varnish seems to have the preference, but the following mixtures have been recommended:

1-3 raw linseed oil and 2-3 Portland cement.
Graphite and lard oil.
Graphite and linseed oil.
Graphite and cylinder oil.
Equal parts of red and white lead mixed with linseed oil.

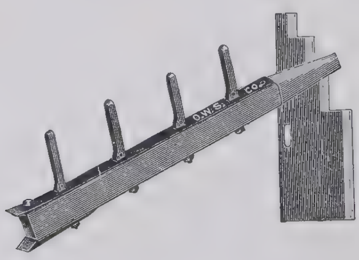
Of the mixtures the one consisting of Portland cement and raw linseed oil seems to have the preference, and is the most practical. (O. Q. B.—'05—No. 560.)

20. *Wrought Iron Pipe.* In the pipe used for this purpose, preference is given to wrought iron over steel, as the wrought iron pipe is not as much affected by corrosion as is steel pipe. It is softer and more easily tapped for service connections, and is more apt to be even in quality. The mills make a special grade of pipe for this purpose called line pipe. This pipe is about 10 per cent. heavier than the ordinary pipe and the thread

is more tapering ; the sockets or couplings on the pipe are longer than usual, and the taper thread in the socket and on the pipe allows it to be screwed to the shoulder, and as the thread almost vanishes at the end of the socket, the pipe is almost at its full strength at that point, and is not as liable to break off close to the joint as would be the ordinary pipe.

21. *Wrought Iron Pipe Fittings.* The fittings used in the work are cast iron. They should be of the best quality of iron, and are made much heavier than the ordinary fittings ; for instance, a 4″ elbow for this work weighs about 48 pounds and a 6″ elbow 74 pounds. There have been no standard dimensions adopted for cast iron screwed fittings for street mains, but each firm makes fittings according to its own pattern. These fittings, however, can be ordered in reducing sizes in almost any way specified. In reducing from one size of one pipe to another in the line, instead of the ordinary reducer, what is known as a swedge nipple is used. This is a piece of the largest size pipe which is drawn or swedged down at one end to the smaller size. Being of wrought iron, it is much stronger, and will stand a greater strain than would a cast iron reducer.

22. *Laying Wrought Pipe.* It is customary to put this style of pipe together on top of the ditch and drop it into the ditch as laid. For the purpose of holding the pipe to the right height, the jack is used.



The end of the pipe which is already in the ditch is placed in the crotch of one jack and the end of the length to be laid is held at a higher elevation in the crotch of another jack; one of the tongs men puts a pair of tongs on the pipe already

in the ditch to keep it from turning while the other two or three pairs of tongs are placed on the length to be laid to turn it up. Tapping the socket or coupling with a hammer marks time and enables the tong men to swing together on the tongs and also makes the pipe screw up better, care being taken not to strike all the time in one place on the coupling with the hammer or it will flatten it. Each length should be examined to see if it is clean inside and has no flat places or defective threads. In case the threads are dirty, they may be cleaned with a wire brush.

Should an offset be desired, or an angle, pipe up to 6″ may be bent cold, care being taken not to try to bend the pipe too much in one place so as to kink it. 6 inch and larger, the pipe should be heated to a cherry red. An easy way to bend the pipe is to support the pipe in two places, heating the pipe in the center and allowing it to bend of its own weight.

23. *Connections to Existing Wrought Mains.* In making connections of wrought iron mains to wrought iron mains already laid, it is customary to use a saddle piece. In putting on the saddle piece, a circle the size of the pipe to be connected is marked on the main pipe at the point and in the position the branch connection is to be made.

With a diamond point or cape chisel the main pipe is now cut through along this circle except at one point where just enough metal is left to hold the center piece in position—the escape of gas is prevented by working soap or clay into the cut.

A short nipple is screwed into the saddle piece and a tee with a plug in the opposite end screwed on the nipple—the connection being made into the side of the tee. After the saddle is fastened in position over the proposed hole in main line, the plug is taken out of the end of the tee and with a sledge hammer and long cold chisel, the center piece is cut clear and driven into the main line. The plug is then screwed tight into the end of the tee. On large sizes the saddle pieces are preferably forged from wrought iron and have two straps. These may be regularly procured for pipe up to 8″ in diameter

with a branch one size smaller than the main line. Saddles for branches larger than 6″ must be ordered special. Sometimes, instead of using a saddle, a fitting is used, made after the Hammon or Dresser style of coupling for a rubber gasket and a follower. This fitting is slipped on the pipe and is made tight by pulling the follower against the rubber packing.

24. *Drip Pots.* Drip pots for the catching of condensation in the main are cylindrical vessels of cast iron and are usually inserted in the line. For insertion in cast iron lines, the drip pot is provided with hubs or bells of the proper size cast on opposite each other near the top. For insertion in wrought iron lines, flanges are cast on instead of the hubs and a set of loose flanges are bolted to these, the loose flanges being screwed on the pipe. The drip-pots have loose covers, the cover is fastened in place with a lead joint, the lead being run and calked into a joint space between the cover and the drip. Sometimes the top of the drip is flanged and the top is bolted on. For pumping out the condensation a vertical wrought iron pipe ¾ or 1″ in diameter is screwed through a 1¼″ x 1″ or 1¼″ x ¾″ bushing, which is screwed into the cover. In making these joints, it is well to use litharge, mixed up with glycerine or a little red lead and litharge, as these make a stubborn joint which is hard to unscrew. The pipe is cut of such length that it almost touches the bottom of the drip, and another piece is screwed on the end projecting above the cover of a length so that the upper end is just below the level of the road-way, in which is set a drip box which protects the pipe and at the same time renders it accessible.

A nipple and socket cast together called a lengthening piece is sometimes put on the top of this pumping piece so that when the thread becomes stripped from the constant screwing on the siphon pump, it can readily be removed and replaced without digging up the street. (O. G. L. A.—1902—Franklin.)

Sometimes the pumping pipe instead of being carried up vertically to the service, is run under the surface to the curb and then brought to the top.

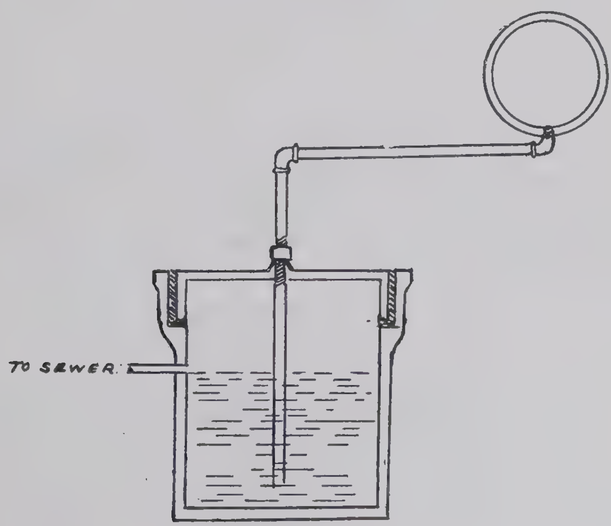
An automatic syphon for the drip is a good thing where drips require frequent pumping, and is perfectly safe if there is liquid enough to keep the siphon sealed at all times and the overflow is conducted over a bank where the end should be arranged where it could not be tampered with and would not freeze. (Stone—'03—Q. B.—No. 109.)

If the overflow from a drip of this kind must be carried into a sewer, there is the danger of the sewer becoming stopped and the water backing up into the main. (Thomas D. Miller.)

There is also danger of the evaporation of the seal and the gas escaping into the sewer, in which case the Gas Company would be liable for damages.—Peoria Gas & Elec. Co.—'03—O. Q. B.

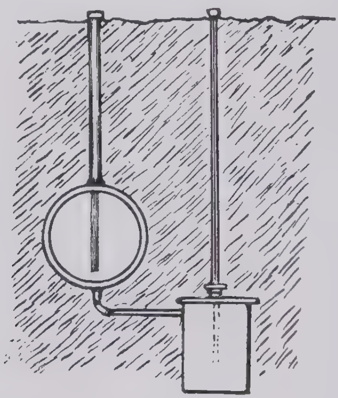
Perkins, '03—Q. B.—No. 109 contributes a sketch of automatic drip.

Description:—The low part of the main to be tapped on the bottom and a small pipe inserted which dips into a seal pot from which there is a fixed overflow. In case of excessive pressure, the gas will escape, but does not permanently destroy the seal. There is also so much water present that a much greater time is required to unseal by evaporation. Emerson McMillin, while Superintendent of the Columbus Gas Works,



equipped that plant with these seal pot drips, superseding the goose neck type in 1883, and as far as I know he is the father of this wrinkle.

An important safeguard for drip boxes is described by Mr. James Somerville, who connects the drips about his works in the manner shown in the cut below. It will readily be seen that the small pipe leading from the main pipe to the pot becomes stopped up, as too frequently occurs in certain situations, the drip will show dry, and yet the main will be half full of water. The safety pipe is run through the main nearly to the bottom, and is carried up as desired.



It is not customary in laying low pressure distribution mains to make any provision for expansion or contraction. Ordinary expansion in iron pipe like railroad tracks will take care of itself if the joints are sufficiently well made. In crossing bridges where the conditions are not ordinary, an expansion joint is desirable. One of the Hammon or Dresser type will be found satisfactory. (Shelton—W. G. A.—1902.)

25. *Protecting Mains from Frost.* For prevention or stoppage by frost it is desirable that fittings and angles be done away with as much as possible. (Dunbar—Q. B., W. G. A.—'99.)

And that the pipe crossing a bridge be enlarged, for

instance, if the main is 4″ and it is enlarged to 8″ when crossing a bridge, this will probably obviate the trouble. (Geo. McMillen—Q. B., W. G. A.—'99.)

26. *Protective Coatings for Pipe.* The thickness of metal employed in making cast iron pipe, and also the character of the metal renders it less liable to corrosion than is either wrought iron or steel. For this reason cast iron pipe is very seldom given a protective coating. When such coating is given, however, it should be applied in such a manner as not to get into the joint space for gas is liable to dissolve the coating and cause a leak. The preservation of both main and service pipes from injury either from corrosion by acids in the earth or by the action of electrolysis, is a subject that has merited much consideration and is productive of many opinions, it being sometimes affirmed that the cost of the protection is greater than is warranted by the increased life of the pipe. (Simpson—'04—Q. B.—No. 116.) (von Maur—'04—Q. B. —No. 118.)

There seems to be three methods in general use for protecting pipe:

Galvanizing:

Coating with a coal tar preparation or surrounding by coal tar concrete.

Coating with cement or surrounding with cement concrete.

The first method does not meet with general favor, it seeming to be the general opinion that the zinc coating was not of any permanent benefit. (Thos. D. Miller, Peoria Gas & Elec. Co., '03—Q. B., No. 103.)

Coating with a coal tar preparation, applied with a brush, is recommended for the prevention of corrosion. Undoubtedly the preparation and application of this coating has something to do with its permanency and effectiveness. If the coating is not perfect, the corrosion will begin at the cracked or defective place and work back under the coating, thus annulling all the benefit. It is said to be important that all the acids in the tar are eliminated. This is hard to do. Favorable results have been obtained both from the application of hot coal tar, into which has been stirred lime to neutralize the acid, and also

from the application of Hickenlooper coating, the specification for which is as follows:

Bring a kettle of tar (20 gallons) to a low boiling point and add 20 pounds of fresh slacked lime, sifted over the top and worked down. Boil down to a paste or a consistency midway between tar and pitch. Let it settle for a few minutes, then add 4 pounds of tallow and one pound of powdered resin. Stir until they are thoroughly dissolved and incorporated into the mixture, then let cool. When ready to use, to each 45 gallons of the above add 4 pounds of crude rubber, dissolved in turpentine to the consistency of thick cream. Heat the mixture to about 100 degrees F., and apply to pipe heated to about the same temperature. (A. G. L. J., 65; p. 886.)

Different methods have been adopted for applying the mixture, the pipes being dipped in some cases and painted in others. Mr. Humphreys said that the best way was to dip the lengths of pipe into the preparation. In this method the mixture is put into a V-shaped trough which is long enough to take the longest length of pipe that is apt to be handled. Along the bottom of this trough is run a steam pipe to heat the mixture to the proper temperature. The pieces of pipe to be coated must also be heated, which can be done either by connecting the pieces to a steam pipe and turning steam on them to give them a test of soundness while they are being heated, or by putting them in a long, square box with a hinged cover, the interior of the box being kept hot by means of a steam coil run along the bottom. When pipes are heated to the proper temperature, they are plugged at both ends to prevent any of the coating from getting on the inside, and are dropped into the hot mixture in the trough. After a few minutes they are taken out, placed on a rack over the trough until the excess of the mixture has dropped off, and then transferred to a drying rack, in which they are left until the coating becomes thoroughly dry and hard. Care must be taken to keep the pieces from touching each other before they are dry and hard, since, if this is not done, they will stick together, and, when pulled apart, the coating will stick to one pipe, and a bare place will be left on the other. Care must also be taken not to get the mixture or the pipe too hot, since

overheating will drive off the more volatile portion of the preparation, and when the coating cools, it will be brittle and liable to chip off. If the proper precautions are taken and fresh portions of the mixture added from time to time to that already in the trough, the coating will be elastic and will cling very tightly to the pipe. The service gang should, however, be supplied with a pot of the preparation, so that after the service is laid the spots where the coating has been scraped off by the tools can be re-coated before filling in the ditch. In some cases, the pipe, as it lies in the ditch, is covered for its whole length with an extra layer of the coating, which forms a roof over it.

The following formula for coal tar paint is recommended:

Coal tar............	8	16
Portland cement.....	1	4
Kerosene oil........	1	3

This was found not to injure iron or steel, and the range in mixture is between the above proportions. It will stick to galvanized iron, and costs 10 to 15 cents per gallon. It is particularly adapted to salt water. The cement neutralizes the acid of coal tar, and the kerosene oil acts as a dryer. The cement is slowly stirred into the kerosene first, and this mixture stirred into the coal tar. It should be freshly mixed up and kept well stirred when applying. (A. C. Cunningham—Engineering Record, July 28, '06.)

The above mentioned protections are not recommended for electrolysis.

As a protection against both corrosion and electrolysis, it is recommended that the pipe be surrounded with a coating of tar concrete, the tar and the gravel, sand or stone to be thoroughly dried and mixed and applied perfectly hot, the pipe to be laid in a wooden trough containing the mixture. (Humiston, '04—Q. B., No. 118.)

In Grand Rapids, about 1899, I began experimenting with the above method of laying service pipes. Later on we adopted it as general practice—which is still in force. We had but little trouble there from electrolysis. This is believed to be largely due, however, to the Street Railway Company

providing ample and proper conductors for their return current, and our belief is supported by the fact that a great many uncovered service pipes installed previous to 1899, are apparently as free from electrolytic action as are the covered pipes." (Walbridge—'03—Q. B.—No. 101.)

A coating about 1-32" thick of either California, Trinidad, Gilsonite or Bermudez asphaltum, combined with petroleum residuum and sulphur, is prepared in the same manner: The petroleum residuum is to be heated to 300 degrees F, 3 per cent. of common sulphur added to it, the same to be cooked to 300 degrees F. until the sulphur is thoroughly incorporated with it; then sufficient of this mixture to be added to the melted asphaltum until the asphaltum is of such consistency that it will not become too soft or run at 120 degrees F., or crack when struck with a hammer at a freezing temperature. The pipes should be dipped in this composition at a temperature of about 225 degrees F. In being laid, if the composition should in any way be removed or damaged, sufficient should be put on with a brush, hot, after the pipes are connected. This composition is said to make a perfect insulation proof against electrolysis. (Watt, '04—Q. B.—No. 118.)

"Boiled tar is as good as cement for protective purposes at a very much less cost. Make a trough a little larger than the size of the pipe to be laid; boil the tar to a consistency nearly of pitch; fill the trough with the mixture. It is an absolute prevention of electrolysis." (Aldrich—'04—Q. B. No. 118.) One of the chief objections to this or any other covering in which a viscous base like tar is used is that there can be no certainty that it will stay where it is laid.

"All our services laid under street car tracks in 1904 were laid in pitch as follows: A square box made of 1" undressed lumber, 1" larger than the outside diameter of the pipe was laid in the trench, extending 3 ft. beyond the outside rails; in the bottom of this were placed, 6 ft. apart, small pieces of wood .5" thick, to keep the pipe off the bottom of the box and allow the pitch to get under the pipe. When the service was so far advanced, the ends of box were closed with clay and hot pitch poured into same until filled to the top, no cover being used on the box, as no filling was done until the

filling had cooled. The cost of laying in pitch was only $2.00 each more than others of the same length. This I believe to be the true solution of the problem of protecting service pipes from electrolysis and bad soil. But the service would be better boxed from main to curb or stop cock; this, of course, would add a little more to the cost. I fully expect to see all services laid in Milwaukee in the future protected in the above manner.'' Gas Distribution in Milwaukee. Bryce McAdam, Pro. Age.—Mar. 15, 1905.)

In general, a cement wash is considered an excellent preservative of iron or steel, and it has been used on the inside of an iron vessel where no oil paints would stand and has been wholly successful. Not all cements are adapted to this method, as the presence of certain chemical constituents and the absence of others is necessary to make such a coating effective. (Lloyd—'03—Q. B.—No. 127.) Humiston, '04—Q. B.—No. 117.)

It is believed that cement coating of about ¼" thickness, will entirely overcome electrolysis.

Gas pipes lying next to cement covered water pipe, the water pipe was not damaged at all, while the gas pipes gave more or less trouble from electrolysis (Shattuck, '03—Q. B.—No. 127.) In order to be a perfect protection against electrolysis, the cement must be free from cracks. The thickness therefore, will vary with the size of the pipe and the manner of laying same. (Lomax, '04—Q. B — No. 116.)

In actual practice it is almost impossible to get a perfect coating of cement. The writer has removed a great many services which have been cement coated for over ten years. Where the cement had adhered the protection was perfect, but there was no section of over 5 feet long where the adhesion was perfect—rust, dirt, or something else had made imperfect the contact so that the pipe was pitted and the value of the entire coating destroyed.—Mastin Simpson.

It seems as if clear cement were considered a better protection than concrete. "It is presumed that by the word cement is meant a concrete of one of the better brands of Portland cement. Such an envelope is not an absolute protection against electrolysis. Its efficiency would depend on

the proportion of cement employed, the intimacy of the mixture and the amount of moisture in the soil in which the pipe thus protected was laid. With a concrete one inch thick of one part, high grade cement, two parts of sand and three parts of one-half inch stone mixed and laid carefully, it is not believed that an efficiency above 60 per cent. could be secured. By this is meant that a pipe so protected and and subjected to the same influences as a bare pipe would last two and one-half times as long as the bare pipe. Such construction for a four-inch wrought iron pipe would cost $11.70 per 100 feet; assuming that cement, sand and stone cost respectively $2.25 per barrel and $1.60 and $1.50 per yard, and that the common hemlock lumber for a one-inch wood box cost $17.00 per M. It would be necessary to use the box, as without it the mixture could not be tamped with sufficient firmness about the pipe.'' (Humiston, '04—Q. B. —No. 116.)

Another method advocated is to construct a cheap trough which is placed under the pipe after it is laid in the trench, and the pipe is held centrally in the box by small pieces of brick or briquettes made from the cement.

''It is found necessary to have this coating on the pipe not less than 1″ in thickness for any size up to 2″ pipe, this thickness being required to prevent cracking. It is advisable to use the very best grade of cement. Much of our pipe (for Pintsch gas) is naturally laid in railroad yards and frequently through cinder filling, and we find this coating not only withstands the corrosive influence of such filling but also is a good protection against stray electric currents.'' (J. A. Dixon, '03—Q. B.—No. 127.)

27. *Main Records.* It has been suggested that it is quite important that a record be kept of all new mains. The measurements for this record should be made before closing the trench. It is advised to cut a mark on the curbstone opposite each fifth bell showing its location and direction. Where several cement joints are made to one of lead, this mark is best cut opposite the lead joint. The marks are of an advantage when barring for leaks, recalking mains, etc., and

it is especially convenient to have some such indicator of each dead end for use when extending lines of pipe. (George T. Thompson, W. G. A.—'95.)

It is further suggested that whenever main work is to be executed, a written order be issued, giving the foreman his instructions. To make it easier for the foreman and to give him a better idea of his work, a sketch should be attached to this order showing the actual conditions as they exist at the time, giving him the mains and locations on the street to be worked on and also mains crossing the street. As many details are given as possible without making the sketch too complicated. This has been found to be very useful and a great saver of time, money and explanations. (George S. Hessenburch—Pro. Age.—July 1, '05.)

It is also suggested that all measurements for street mains should be made, not only from the curb, but also from the property line, as the property lines are not so subject to change as are the curb lines on a street.

28. *Refilling Trenches.* In refilling trenches dug for either the laying of mains or services, the dirt should be put back in such a manner as not to force the pipe to one side of the trench, the men working with railroad tamping bars in pairs from opposite sides of the pipe. Trenches dug for the laying of mains with cement joints should not be refilled until the joints are set, as the tamping of the earth is liable to jar the pipe and crack the joints. The dirt should be well tamped on both sides of the pipe at the same time, and not more than from 3″ to 6″ of dirt, according to its character, should be placed in the trench at any one time. Custom, as well as good business policy, would indicate that all openings in the streets or alleys should be left in as good condition as found. The dirt should be thoroughly stamped back in place. In some places it is allowable to settle the dirt by flushing the trench with water, but as this softens the bed on which the pipe lays, it may cause the pipe to settle unevenly, and is, therefore, not considered the best practice. Sometimes the dirt removed can not be used for refilling on account of the presence of ashes or because the clay nature of the soil will not let it settle properly.

In such cases, the dirt should be removed and the trench refilled with sand. Some city ordinances specify that this method of refilling should be followed in all cases. If the street is paved, a proper foundation should be provided for the pavement, and in most cases a concrete base is preferred, even when other bases have been originally used, as the use of the concrete base forms a better foundation for the pavement, and it will not be liable to settle. ('04 Q. B.—No. 101—Enright—Philo Jones — Cobb — Walton Forstall — Whipple — Frank Hellen.)

29. *Testing Mains.* New mains should be tested for tightness before being covered. When the piece of main being laid is an extension of an old main, it is usually connected to the old main, and the test for tightness is made with gas pressure. After such a length has been laid as to warrant going to fill in and close up the ditch, the open end of the pipe should be tightly plugged and pressure allowed to come on the new pipe by removing the bag or stopper by which the gas has been shut off.

In case the connection has not been made to the new main, a temporary connection to supply gas for testing may be made. Each joint should then be painted with soap suds and examined for leaks which will be indicated by bubbles at the point of leakage. Especial attention should be paid to the bottom of the joints. Any joints found to be leaking must be gone over and again tested. When all are tight, the ditch can be filled in. Where gas pressure is not available, or even in some cases where it can be had, but a test at a higher pressure than can be obtained from it is desired, the pipe is put under an air pressure by pumping air into it until a pressure of two or three pounds — equal to four or six inches of mercury — is reached. The joint should then be examined for leaks as described above, and the pressure watched to see if it holds up. Indications afforded by the steadiness of the pressure are liable to be rendered worthless by change of temperature, and the temperature conditions must be noted and allowed for, when the hold-up of the pressure is relied on as the sole means of determining the tightness of the pipe, and for

certainty, it is necessary to examine joints in each case. It has been suggested by A. J. Vanderwhite, Pro. Age, Oct. 2, '05, that the portable compressed air apparatus used for testing gas pipes under pressure could be used for supplying air under pressure to pneumatic tools for cutting pipes and calking joints. The testing of gas mains under higher pressure than that supplied by the gas need not materially increase the cost of making cement joints. Cement joints on large mains may, with proper organization, be tested and filled in 24 hours after the pipe is first laid, if necessary, and if the joint is properly made, it may even be tested in a shorter length of time than that. The test is used more to detect defective castings than defective joints, for if the joints are properly made up and good cement used, the leaky joints will be very few, and the cost of cutting and replacing these joints will be very small in comparison to the total number made. (Question No. 512 — Q. B. — '06.) (Cadwaller—Gillingham—Goudy—Forstall, etc.)

30. *Other Pipe.* In addition to the ordinary bell and spigot cast iron pipe, a pipe is made with a ball and socket joint. This is not used in ordinary practice, and is only used where great flexibility is desired, as, for instance, in crossing the bed of a stream.

In English practice a cast iron pipe is made, the following description of which is given by Bryce McAdams, Progressive Age, March 15, '05:

"I think it is far ahead of our bell and spigot pipe, and I

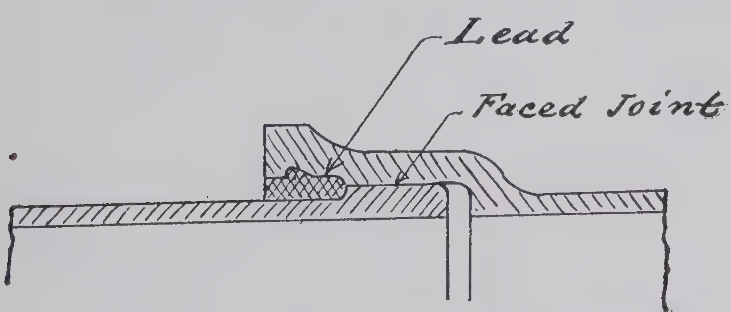


FIG. I. BRITISH JOINT FOR CAST-IRON MAINS.

would gladly welcome its introduction. The hub is slightly deeper than that made in this country, the inside of which has a projection of 2.5 inches wide, beginning at back of hub; this is turned off with a perfectly smooth surface. The spigot has no head, but is cast with a projection conforming to that of the hub; this is also turned perfectly smooth on the face or surface, and fits snugly into the hub. When about to lay the pipe the faced parts are coated with a mixture of red lead, white lead and oil, the spigot end is carefully entered into the hub and driven home with a block of hard wood, by pounding on the hub of the length just laid until within .5 inches of being home. The pipe when thus laid is almost perfectly gas tight, but a lead joint is also run in the usual manner on the part of the hub not taken up with the turned and bored joint. No yarn is used, it is not necessary. In cases of larger sizes, after the pipe is properly entered, it is left there until another length is lowered into the trench, and this length, while still hanging in the sling, is used as a ram to send the other length home.''

Cast iron flange pipe is also made, but it is not used for street mains. Flange joints allow of the easy removal when desired of any one of the various pieces of pipe. They are, however, very rigid and on long street lines of flange pipe, one or more expansion joints should be provided to relieve the pipe of the strain that would be thrown upon it by its expansion and contraction under the influence of the temperature. The following cements are offered for use in connecting up flange joints: Take ordinary pine tar and mix it with dry oxide of iron. This putty will make as good a joint on a faced or rough flanged joint as red lead putty at one-tenth the cost. It will harden as soon as red lead but is very adhesive under pressure. (George Light—O. G. L. A., 1902.)

Litharge joints are made by mixing litharge with commercial glycerine to the consistency of a thick paint with which the threads are heavily coated and then screwed tight. It sets quickly from a few minutes to a few hours, depending upon the consistency of the mixture and the age of the litharge. A thick mixture and fresh litharge set very quickly

and a thin mixture and old litharge set much slower. Only a little should be mixed at a time and after once mixed, it should not be stirred again or else it will never set.

Red lead and white lead joints are made by either using the ready mixed lead paints, or by mixing the powdered lead and boiled linseed oil. Both will not set but just dry up like any other paint. The respective merits are that litharge makes the best joint for all purposes where the pipes are not subjected to jar. It is not affected by heat, cold, water, gas or acid and is extensively used for ammonia work and for high pressures. The joints are very hard to disconnect after the litharge becomes hard. Lead joints answer for all common work on water, steam or gas under ordinary pressure. Oil alone or asphaltum will do the same and if the pipe threads do not fit the fittings, no material whatever will make a tight joint.

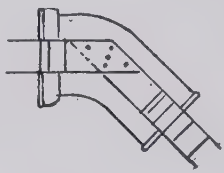
Red and white lead mixed to a soft putty makes the hardest joint; white lead is too soft by itself. Litharge will not set so hard or as quickly as red lead. (Bertsch—Bunby—John Witten, England. O. Q. B. '05—No. 561.)

"The Universal" pipe is a modification of a flange joint allowing greater flexibility. The experience regarding the use of this pipe so far is not conclusive. (Questions No. 497 and 515.—O. Q. B.—'05.)

Cast iron pipe is now also made with plain ends and put together by a rubber coupling of the Hammon or Dresser style. It seems as if this would make an ideal main, but no figures are available either regarding costs or results. A substance called lead wool for calking joints on cast iron bell and spigot pipe is now on the market, but it has not been used for sufficient length of time to determine its usefulness. It has the advantage of dispensing with the pouring of the hot lead,—the joint being driven cold. It is claimed to be as cheap as the joint made in the ordinary manner.

A fibre or paper gas main has also been tried. The use of this pipe has not been found satisfactory, as the life appears to be very short. The cost is just about the same as the cost of iron pipe. (Copley and A. S. Miller — W. G. A.—'06.) (Keys and Waters—O. Q. B.—No. 505—'05.)

31. *Checking Length of Bends.* To check the length of one-eighth and one-sixteenth bends, nail two strips of board together at the proper angle, and from the drawings mark on one leg the proper position of the face of the bell and on the other the end of the spigot. Lay the board on the side of the special over the center, and a glance will show if the length is according to specifications or not. Lines may be drawn on this same contrivance for all the size. (R. C. Griswold.—O. Q. B.—'06.)



32. *Impromptu Resistance Meter.* Donald McDonald gives a description of a device for measuring the amount of gas, air or steam passing through a pipe without a meter. "This device is called a resistance meter, and is constructed as follows: The pipe is parted at any convenient point, and a sheet-iron diaphragm inserted, the diaphragm containing one or more holes of known size. The size of these holes must be governed by the amount of resistance which can be produced in the pipe without inconvenience. The pipe is then tapped on both sides of the diaphragm which causes the resistance, and one-half inch pipes are then led to any convenient point for taking observations. When the two pipes are joined by rubber tubes to the two ends of a U gauge filled with water, the reading of the U gauge will always show the amount of resistance which the diaphragm causes to the flow of gas through the pipe. By taking and recording frequent observations of this resistance, the daily delivery can be very closely ascertained, while for the purpose of ascertaining instantly just how much gas or air is actually flowing through, the device is a better one than any other form of meter. We have used a device of this sort for the last ten years, and have always found that it is exceedingly convenient and always accurate. For the information of anyone intending to construct such a gauge, I will say that a sheet-iron diaphragm

with a circular hole 3½ inches in diameter passing 300 feet per minute of carburetted water gas will cause a resistance of 2 inches of water. If the resistance is multiplied by 4, the delivery will be doubled. With this for a basis, a meter can be constructed to meet any conditions of delivery desired, and resistances can be tabulated that are likely to arise, and a table can be made up by means of which the resistance in inches and tenths can be read into cubic feet delivered per minute."

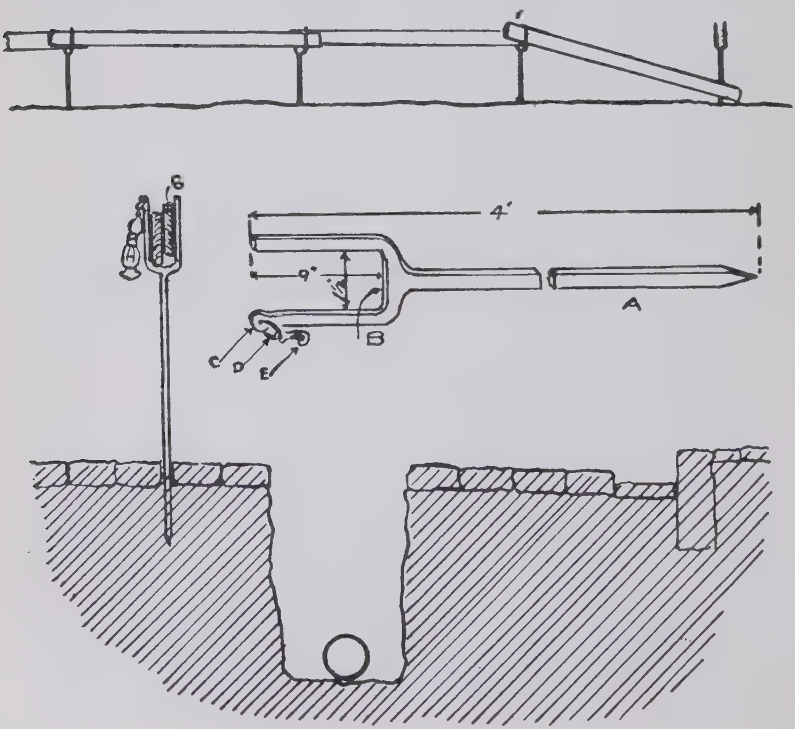
33. *Bending Cast Iron Pipe.* "I send you this rough sketch of an old wrinkle, not in general use, for few there are that think of bending cast iron. My first attempt was at a a lumber camp in Calvareras County. Our cook could not bake bread in the stove oven on account of the cross-piece between the lids having become bent or warped so that it allowed too much cold air to pass over his oven. He asked me if I could straighten it. I thought that the same medium that bent it could unbend it, so by putting it into the forge and getting it to a bright cherry red, then placing it on the anvil upside down and with a gentle pressure from the sledge hammer brought it down straight again. So, when occasion required to swing around a curve with nothing but straight lengths of cast iron pipe to do it with, I have done this, building a fire around two or more pipes, as the case might be, and letting them warp down until the center pier wall touches, then knock out your fire, using no water to extinguish it. I have made some very pretty bends in this way for the water company, withstanding 150 pounds pressure. You pile your wood after the manner that a blacksmith heats his wagon tires." (T. R. Parker, Pro. Age.—Sept. 15, '04.)

Having occasion to remove some 200 feet of 12″ main from its position on supports overhead in the works yard, the device of which a description follows, was adopted to avoid the labor otherwise necessary in cutting out lead joints. The "basket" was formed from three pieces of old sheet iron; two of them, the end or front pieces, were alike, U-shaped, the inner semi-circle fitting the outside of the main and the outer one being some 10″ greater in diameter; the edge was rectangular, about 18″ wide, and bent to fit the outer edge of the front

pieces, to which it was attached by "knees" of light iron, secured by rivets and stove bolts. A number of 1″ holes were roughly punched in the bottom for draft, and handles were attached at the side, through which an iron rod or short piece of pipe might be passed across the main to hold the basket in place when in use.

It was intended to employ hot coke in "burning out" the joints, but owing to the small body of fuel and its consequent rapid cooling, this was not found satisfactory. Using dry wood, however, the lead was quickly melted. Whenever possible the lengths were drawn apart with screwjacks, but on most of the joints this basket was used, and proved very convenient and satisfactory. (George T. Thompson, Basket for Melting Out Lead Joints.—W. G. A.—1894.)

34. *Fence for Ditches.* In street work, when ditches have to be protected against passing vehicles, etc., the usual course



is to make a more or less efficient fence out of barrels, planks, ropes, or anything else that is handy. Gas companies, however, constantly working in the streets, will find that it will pay to cover this detail systematically with a better device than the heterogenous arrangement above referred to.

The scheme shown by the cut, in use in Boston, Mass., commends itself so for simplicity and effectiveness that it is herewith reproduced for the benefit of our readers.

In it, any desired number of iron or steel rods are made, pointed at one end, forked at the other, as at A–B. These rods being driven into the ground at suitable distances apart, alongside of and parallel with the open ditch, form strong and secure supports for boards or planks dropped in the forks edgewise, to form a guard or rail.

(Guard Fence for Street Ditches, Jno. Gimper. A. A. G. W. —1891—1900.)

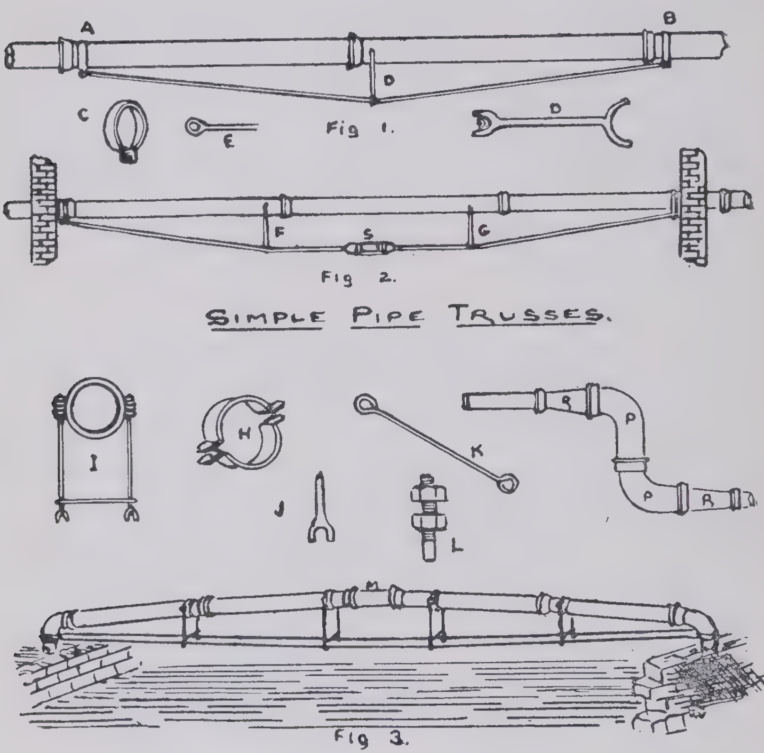
35. *Trusses for Suspended Mains.* In the running of pipe about a gas works and main about a city, it frequently becomes necessary to truss several lengths of pipe so that they will be self supporting. If the distance to be spanned is over 40 or 50 feet, it is best to call in the service of a professional engineer to design a suitable and economic truss—unless the superintendent feels able to do this for himself. If less than the above distance the trusses shown by the cut will be found to be all sufficient for the purpose and to be readily and cheaply made by a good blacksmith.

Fig. 1 represents two lengths of pipe, strengthened by a single tie rod. This has an eye at either end as at E, and is attached to the pipe by means of the clamps A B, shown in detail at C. The distance strut D in the center is kept in place by compression only.

Fig. 2 represents three lengths of pipe, spanning say a driveway between buildings, trussed in the same manner but with two vertical struts F G and a "turn-buckle" S for tightening up. Where this pipe is of a large size, two tie rods should be used, as in the next example. In this case the struts F G will, of course, be in pairs, as at I, and the shape of clamps will then be as shown in detail at H.

A horizontal rod, K, of light half round iron, should be used at each pair of struts, I, to keep the tie rods parallel and the right distance apart. The lower ends of the struts should be forked as at J, while the upper ends should be provided with two nuts each, as at L.

Fig. 3 represents this last form of truss, enlarged and



supporting four lengths of pipe and a key piece, M, crossing, say, a canal of 40 or 50 feet in width. In detail this is like the others above, differing only in having an additional number of vertical struts and at the ends, clamps being attached horizontally around the riser elbows at N O.

The dimensions, weight of iron to be used in rods, etc., must in each case be governed by the size and weight and span of the pipe of the individual case in question. Such work

should be carefully laid out beforehand, and the following points remembered :

First, as such trussed pipe is under a slight strain, the lead joints should be made with unusual care, and as deep and strong as possible.

Second, as the pipe itself is one member of the truss, in tightening up the turn buckles, S, care should be taken to just "take the weight" off the pipe without "starting" the lead joints.

Third, as such pipe is exposed and subject to strain, unusual care should be exercised to select only sound and truly cored lengths. It is a good plan to use "extra heavy" pipe in this work. A few lengths of such can usually be procured of the local water company.

Fourth, if the riser elbows, P P, be made of two sizes larger pipe (connected by reducers, R R) than the run of the pipe, Q Q, there will be much less liability to deposits and stoppages of naphthaline, etc., in exposed places around bridges, etc.

Fifth, all such work should be well painted.

If it is desired to house in a trussed pipe of this sort from the weather, a suitable covering of wood, or of corrugated or sheet iron, may be made, and may rest directly upon the pipe itself.

After a trussed pipe is once erected, do not assume that it will take care of itself for all time to come, but make periodical inspection of it to see that all joints and nuts are tight, threads not rusting, etc. If this be done the life of an iron truss will prove three times as long as a wooden one, and all attendant dangers of dry rot and sagging in the latter are avoided.—A. A. G. W.—1891—1900.

36. *Enlarging Holder Pipes.* It frequently happens that it is desirable to increase the size of the holder pipes, and excavation either under a brick or steel tank is not only an expensive and dangerous method, but one that requires more time for the installation than can be afforded. In King's Treatise, Vol. 2, 9, 195, is shown a flexible outside stand-pipe of which design there are three examples in this country. The first was at Danbury, Conn., installed by Prof. Edgerton;

one at Staten Island, of 12-inch cast iron pipe, and one at New Orleans, of 24-inch x 30-inch steel pipe. The latter two were installed by Mr. Fred. H. Shelton. We herewith

reproduce a photograph taken of the installation made at Clifton, Staten Island, at which place Mr. Thomas C. Horthorn is in charge. The three flexible joints shown are made by

the flanges of the elbows and tees being tongued and grooved and held together by bolts passing through the tees and through the elbows at the point where, ordinarily, cleaning holes are provided.

The first installation was made at Ivry, France, some 60 years ago. We are informed that no naphthaline trouble has ever been experienced with this method of articulated outside piping.

37. *Cutting Cement Joints.* The heating of cement joints by building a fire around them will soften and break up the cement, so that the joint can be readily cut out.

38. *Booster Lines.* The rapid growth of cities has made it necessary to provide some means for the supplying of gas to the outlying districts, in many cases the mains originally laid for distribution being much too small. For this purpose a "Booster Line" is installed, this being a line running direct from the main distributing station or manufacturing plant to the outlying district, or it may even be a belt line encircling the town. The gas is forced through this line at a relatively high pressure, from 5 to 15 pounds being carried, the gas being pumped by either a rotary blower or a compressor, as circumstances indicate best. While some cast iron lines are used for this purpose, on account of the liability to fracture and the high leakage when the fracture occurs, the preference is for wrought iron or steel line pipe laid with screwed joints in much the same manner as that described in the "Laying of Wrought Iron Mains for Low Pressure Distribution," special care being taken, however, that the joints are made perfectly tight, the line being tested with compressed air to at least double the pressure it is expected to carry. Where the pressure to be carried will exceed 10 or 15 pounds, it is desirable to lay wrought iron line pipe and in sizes 6" and larger, pipe—with plain ends, using the Dresser or Hammon style of coupling. Originally the gas was pumped through the "Booster Line" and stored in a holder, afterwards being taken out of the holder through a larger line into the main distributing system. This holder should be provided with an automatic valve to shut off the supply when the holder becomes full, and also with an

electrical connection which will indicate at the pumping station the height of the holder.

39. *Governors.* The practice now is to dispense with the holder on account of the cost of installation, maintenance and operation, and instead of using the holder, distribute the gas directly from the high pressure "Booster Line" into the main low pressure system, a governor being used to reduce the pressure. These governors are very sensitive, and will readily reduce from 20 pounds down to 2 or 3 inches of water pressure, but where the pressure carried on the "Booster Line" is greater than 10 pounds, better results can be obtained by placing two governors tandem, the one governor reducing from the initial pressure down to about 5 pounds, the other reducing from 5 pounds down to the pressure to be carried in the mains. These governors should also be installed in duplicate, so that in case of the failure of one set of governors to act, the other can be depended upon. A convenient method of installation is to place the governors in a pit in the street. The governor pit described by Bryce McAdam, in "Gas Distribution at Milwaukee," 1905, is as follows: Our governor pits are 7 ft. 8″ x 12 ft. 4″, with a 12″ brick wall laid in cement mortar on a concrete bottom 8″ thick. The roof is concrete, arched on 9″ beams, finished 4″ below the grade, and on top of which is laid a dry mixture of crushed stone and gravel, forming a macadam road. In one corner of the roof (nearest to where the gauges are) is placed a square manhole, with a locking device, and counterbalanced so that when the cover is unlocked and raised, it remains standing on end until again closed and locked. The work done so far has been entirely satisfactory, and we will go on extending the system as demanded by an increased business.

To insure perfect safety, an automatic seal or blowoff should be provided at each governor. These may be sealed off with either mercury or a non-freezing oil. On account of the expense, the oil is preferred for the larger sizes.

40. *Cross Country Artificial Gas Lines.* The consolidation of several Gas Companies under one head has made it convenient and economical in operation to place the main manufacturing plant in one town supplying the surrounding towns

by high pressure lines laid across the country. These lines are operated under varying pressure from 5 to 50 pounds, about 30 pounds being the average. The gas is pumped into the lines by compressors which are arranged to run according to the demand, pulsation tanks being placed near the compressors to steady the flow of gas through the line. There is no storage other than the cubical capacity of the line. In some cases, however, it seems to be considered advisable to place reserve storage tanks at the further end of the line. These reserve storage tanks being wrought iron riveted cylinders, tested to stand a higher pressure than carried on the line and having usually a capacity of 3,000 to 7,000 cubic feet of gas at from 30 to 50 pounds pressure. The gas being under pressure in these tanks gives some reserve and flowing out of the tank in time of extra demand, aids in equalizing the pressure. The moisture in the gas is taken care of by means of extractors, consisting of a vessel containing a series of baffle plates placed near the compressing station. In addition to this, drips with blowouts are placed in the hollow places nearest the pumping station, usually two or three feet beyond the lowest point in the direction in which the gas flows. These drips are blown out at stated intervals. When this method of distributing gas was first inaugurated, there was some fear that the compressing of the gas would cause some depreciation in candle power or in the quality of the gas. These fears do not seem to be well founded, as recent experiments have shown that while there may be some depreciation, it is not appreciable enough to affect the quality of the gas. The pipe used in installations of this character is preferably wrought iron screwed pipe for the smaller sizes and wrought iron plain end pipe, using the Dresser or Hammon coupling for the larger sizes, 6″ or over. The use of the Dresser or Hammon couplings enables the pipe to be laid very quickly, makes an absolutely tight joint, and in case there is no fear of corrosion a lighter weight pipe may be used with these couplings. If cast iron fittings are used, they should be of the extra heavy type used on natural gas cross country lines. Gate valves are placed at convenient points in the line, so that in case of a break any section can be isolated. The line is

tested by compressed air furnished by a compressor driven by a gasoline engine or electric motor mounted on a portable testing rig. When leaks are found which can not be screwed tight or calked, they are repaired with a leak clamp of the Hammon style. The practice of protection from corrosion now in use for low pressure distributing systems is being applied to high pressure lines. The gas is supplied from the high pressure to the low pressure system through regulators placed in much the same manner as are those for "Booster Lines" in the larger cities. One advantage of a high pressure installation of this character is that, if deemed advisable, high pressure services may be taken directly from the line as it goes across the country and where the consumers are scattered over a great extent of territory, branch mains may be laid, small in size, say 1¼" or 1". These mains feed directly from the high pressure system. In this case each consumer is equipped with an individual governor, and a safety blow-off. The services are usually either ¾" or ½" in size, screwed directly into a tee which was placed in the line when it was being laid or else the connection to the main line is made by a combination tee and saddle piece, having a lead gasket.

It will be noticed that on account of the decreased sizes of mains and services, the cost of an installation of this character will be much less than that of the ordinary kind. Neither mains nor services need to be graded, as there is no condensation to be taken care of.

The governors reducing the pressure for a town system should be in duplicate, and may be placed in a pit or in a governor house built for that purpose. In either case they should be placed in a position readily accessible for cleaning and repairs, and should receive periodical attention, as a slight wearing of the seat or valve will cause quite a difference between the normal working and the actual closing off pressure.

(For an extended discussion, see H. L. Rice on "High Pressure Gas Distribution of Today."—A. G. L. A.—1905.)

(For further notes on cross country lines, see Natural Gas Section.)

The following wrinkle is given as a suggestion for connecting of services and individual governors:

"To install a high pressure service, it has been necessary at the main to use a saddle, a corporation cock and two street elbows, raising the service some 8 or 9 inches above the main, and making a connection that was more or less weak, and one that was apt to break in cold weather. At the house end a complicated arrangement of pipe and fittings was required to properly connect up the governor and seal, and as this usually lay close to the meter considerable room was taken up. This method of connecting was not only unsightly, but quite objectionable, particularly so if the service ran directly into the kitchen or living room, as is frequently the case where no basement exists. The combination saddle and tee A, permitting of a shorter and more rigid connection at the main, and the seal B, small and compact, because it is made to hold mercury instead of oil, are the only novelties in this wrinkle, but a comparison of the two drawings will show at a glance the superiority and neatness of one over the other. The opening at the top of the tee A is for the purpose of inserting a wooden plug so that the gas can be shut off temporarily until the curb cock is reached, when it is withdrawn and the plug replaced. In both drawings the services are made to appear as if they extended a foot or more into the basement, but this was done merely to show a little more clearly the position of governor and seal. In practice the whole connection is twisted and crowded into a more compact mass, so that it does not occupy as much room as indicated.

"Both the saddle and tee, I am told, were designed by Mr. Johnson, formerly of Hammond, Ind."—Lester F. Price, Western Gas Wrinkles—1905.

41. *Natural Gas Long Distance Lines.* The distribution of natural gas from the place of production to the place of consumption has become quite a business within the last ten years. In many cases the point of production is many hundred miles distant from the point of consumption. In some cases the natural pressure of the wells is sufficient to force the gas through the line, but in a large number of cases the gas is forced through the line by means of compressers driven by steam engines, the steam for which is furnished by boilers,

using either natural gas or coal for fuel, or the compressers may be driven by natural gas engines. In some cases these engines are direct connected to the compressers; in other cases the power is transmitted from the engine to the compresser by a belt. As each pumping station is so situated and the circumstances surrounding it are such that it becomes a problem in itself, this makes it necessary that the size and kind of compresser, the speed at which it should run, and the power which should operate it is a problem which must be studied by an expert in that line and determined for that individual case. It is impossible in any article of this kind to give any rules or description which will be of any advantage.

42. *Surveying the Line.* The cost of material and labor on a cross country natural gas line is such that it is necessary that the shortest possible distance be taken; in consequence of this a survey is usually made of the line. This survey takes as straight a line as possible between the pumping station or point of production and the city or town where the gas is to be consumed. After this survey has been made by an engineering corps, the practical pipe layer having experience in the business is usually sent over the line to determine what deviations from the straight line are necessary to make good work. This man takes notice of what creeks and rivers are to be crossed and determines the best possible point for crossing the same, as there is always some danger of a freshet or high water washing out the line and possibly putting the line out of commission at a time when it is most needed. Inasmuch as the high pressure carried on these lines makes the danger from leakage more pronounced than common, it is well also to keep the line as far away from any building as practicable. After it has been determined on what line the pipe should be laid the right of way men are sent out to secure the right of way through the land over which the pipe goes.

43. *Pipe Used.* At this time, too, the pipe is ordered for the line. As the pressure decreases with the distance traveled by the gas from the point of production, in order to convey the same quantity the pipe is enlarged, for instance, at the point of production the line may be 6″. This may be enlarged

successively to 8″—10″, and finally, at the point of consumption the conveying line may be 12″ in diameter. Some high pressure lines have been laid using the ordinary bell and spigot cast iron pipe with lead calked joint, but this has not been satisfactory, as the joints continually leak, the expansion and contraction in the pipe apparently loosening them up. Some cast iron pipe has been laid by using rubber couplings, and this would make an ideal line since the cast iron pipe would be much less liable to corrosion than would the wrought iron, and it also costs less. The lower first cost, however, of the cast iron pipe is largely offset by the cost of transportation. The cross country line is often from 4 to 8 miles away from the nearest railway stations, and sometimes it is even a greater distance than this, and on account of the increased weight the cost of hauling the cast iron pipe is much greater per foot than is the hauling of wrought iron. For sizes 6″ and lower, the preference of natural gas men appears to be for a wrought iron screwed pipe, commonly called line pipe. This pipe is a trifle heavier than the ordinary merchant pipe, and the thread on both the coupling and the pipe is made with a taper, so that the pipe screws up to a vanishing thread at the shoulder.

44. *Laying Screwed Pipe.* The pipe is screwed together on top of the ditch and afterwards dropped in. In laying the end of the pipe which is already in the ditch is elevated to about the top of the ditch on a jack or a skid placed across the ditch. The end of the length about to be laid is then inserted in the coupling of this length and the other end placed at a higher elevation on another jack, care being taken that both lengths are exactly in line. The pipe is then turned by the hands to start the thread. After the thread is started, and the foreman is satisfied that it is not crossed, but is going true, the pipe men place their tongs on the pipe. Usually one set of tongs is placed on the pipe already laid as a hold back to keep it from turning, and from three to four pair are placed on the pipe to be screwed up. On 6″ pipe it is customary to use 4 pair of tongs to screw up, with two men on the handles of each pair of tongs. The foreman beating time with his hammer on the coupling enables the tongs men to swing together

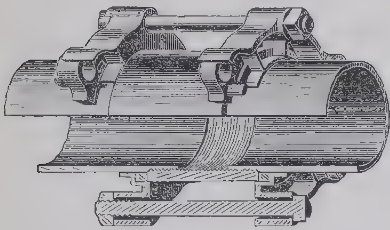
on the tongs. After the length is screwed up tight, the rear skid or jack is removed, and the pipe is carefully allowed to drop into the ditch. The end of the pipe is then lowered on the first jack to about the level of the surface of the ground, and the operation is repeated. One man is usually detailed to go ahead and inspect the threads and see that they are clean and that none of them are flattened. This man will also put whatever dope is to be used on the thread. Any of the preparations enumerated in the section of "Low Pressure Wrought Iron Pipe Laying" will be found satisfactory, but heavy black asphalt varnish is commonly used. The uneven nature of the ground over which the pipe is run sometimes makes it necessary to bend the pipe in order to avoid a strain on the coupling; this bend also allows for contraction and expansion. In this case it is customary to build a fire of wood around the pipe; the pipe is then allowed to bend, usually by its own weight, so as to fit the contour of the ground. Care should be taken so as not to make too short a bend in one place. It is remarkable, however, how easily and how well an experienced man will bend wrought iron pipe of almost any diameter.

It is customary to put in gate valves at stated intervals along the line, so that in case of a break any section can be isolated. A gate valve is also placed where each branch line is taken off from the main line for the purpose of shutting off the branch line should it be considered necessary.

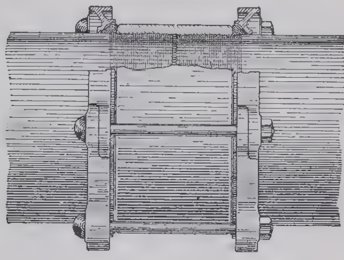
45. *Fittings Used.* In case cast iron fittings are to be used, they are of an extra heavy pattern especially made for that purpose. In addition to the thread they have a recess at the end so that in case of leak this recess is poured full of lead which is then calked tight. It is not considered good practice to use bushings, as they are liable to become cracked or broken, but fittings are usually ordered in reducing sizes or else the size is reduced by the use of a swedged nipple which is a short piece of pipe of the larger size drawn or swedged down at one end to the smaller size.

If a leak develops at the end of a coupling which cannot be calked tight it is repaired by the use of a collar leak clamp. If the coupling is split and it is impracticable to shut the

pressure off the line to make repairs, a split sleeve which completely covers the coupling and extends each way beyond the ends is used to make repairs.

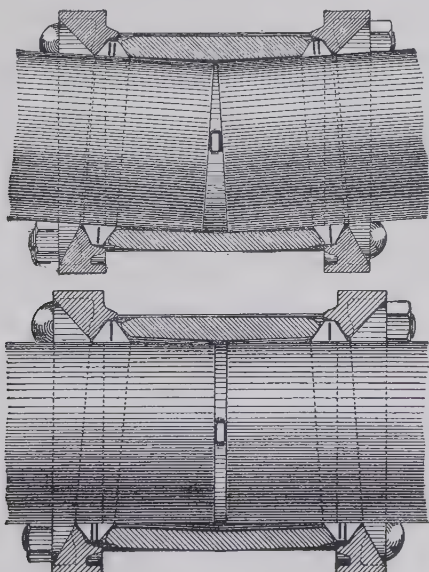


Dresser Leak Clamp.



Hammon Leak Clamp.

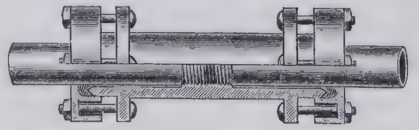
46. *Plain End Pipe With Couplers.* For pipe 6″ and larger it is considered the best practice to lay plain end pipe, using couplings of the Hammon and Dresser type. This variety of joint is satisfactory in every way and has a number of advantages over the screwed couplings for the larger diameters. It makes a much tighter line thus reducing loss from leakage. The cost of laying is greatly reduced, the cost of coupling the



Hammon Coupler.

pipe and filling the ditch being only 20 to 40 per cent. of the cost with the screw pipe. It overcomes the trouble due to the expansion and contraction of the pipe lines without resorting to bends. It enables the pipe to swing more or less, it adjusts itself to the inequalities of the surface (this is especially true of the Hammon coupler), it cheapens the first cost because no threads have to be cut, it is not so easily injured in transportation, and is efficient in preventing electrolysis in localities where electric roads are operated. When pipe is laid with these couplers it is put together on skids on top of the trench. Ratchet wrenches made for the purpose are used to draw up the bolts of the couplings, care being taken that the bolts are drawn up evenly all around the joints. After the pipe has been made up the pipe is carefully lowered into the ditch. For this purpose it is convenient to have a horse made of 4 x 6 timbers with 2 x 4 legs very strongly braced. A series of these horses are placed across the trench. The end of a piece of 1″ rope is fastened to the horse. It is then passed down around under the pipe, brought up again and a turn or two taken around the horse. After the skids are removed the pipe is carefully lowered into the ditch by playing out a little rope at a time, care being taken that the joints are all lowered evenly and are kept in as near a straight line as possible. If the joints are not lowered evenly the leverage of the pipe might crack the center ring and would be very apt to pinch the rubber on one side and force it out on the other. If a very heavy pressure is to be put on a line of this kind the line should be braced where fittings or bends are to be used so that the joint may not be forced out.

47. *River Crossing*. In making a river crossing, if the river is not too wide, the pipe may be put together on the one side and pulled across, or in crossing wide and deep streams it may be laid from a scow. The river bottom should be sounded



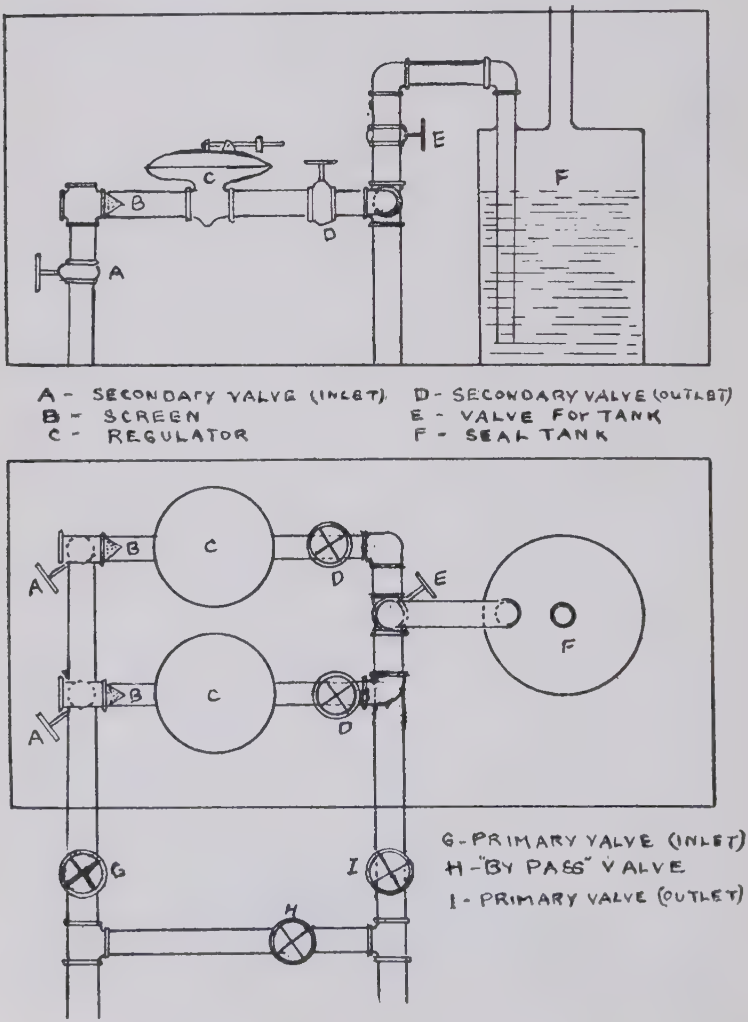
River Sleeve.

and excavated to secure as good a bed for the pipe as possible. The heaviest pipe is used, and the joints are connected by a river sleeve. This sleeve is threaded in the centre so that the pipe can be screwed into it, and in addition the ends are packed with rubber packing made tight by clamps drawn up with bolts. After the pipe has been properly bedded, hooks are driven over it to keep it in place.

48. *Testing the Line.* After the line is completed the gas is turned on, the dirt is blown out of the line and the line tested for leaks. Long lines are blown and tested a section at a time.

49. *Regulators.* It is customary to place regulators at the city line. These regulators are usually placed in a regulator house, and reduce the pressure to something less than 30 pounds for an intermediate line going through the city. Gate valves are placed outside of these houses, so that in case of accident the gas may be shut off from the outside and the house isolated. The regulators in these houses are placed in duplicate, and besides this a by-pass is run across from the inlet to the outlet, back of the gate valves, which isolate the house, so that in case the house is shut out at any time the line may be fed through the by-pass. It is also convenient to place a cross in the riser pipe coming up from the ground to supply the regulator. A conical screen inserted into the supply pipe through the end of the cross opposite the regulator will catch the scale and dirt, and prevent it from damaging the valves. If the shut-off valve is placed below the cross, the screen may be readily removed for cleaning. The intermediate pressure line is run into the city, and regulators placed around the city in such situations that the gas may be fed evenly into the various parts of the distributing system. These regulators are also placed in duplicate, and have by-passes in much the same manner as the high pressure regulators They reduce the pressure from 30 pounds say to about 4 ounces, which is the average pressure carried on the low pressure natural gas system. Liquid seals, or a blowoff sealed with a non-freezing liquid, is placed with each set of regulators, the connection to this blowoff being of the same size as the outlet connection to

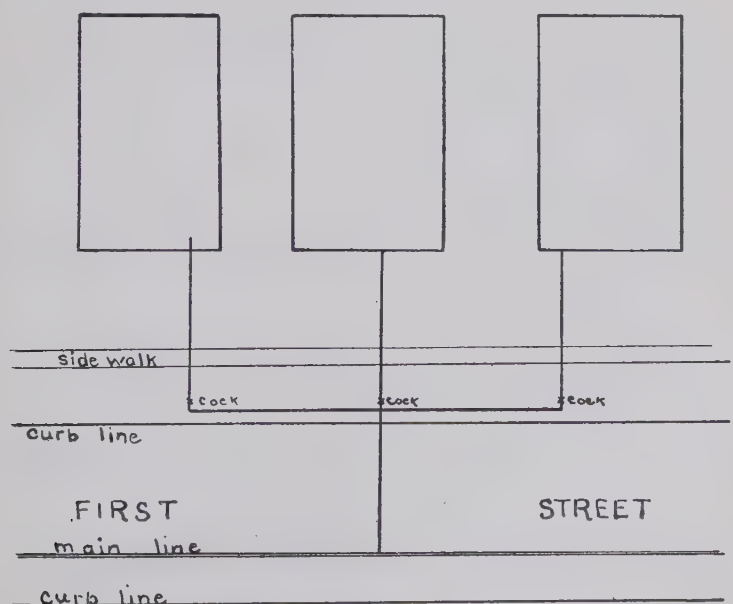
the regulator, and the outlet from the blowoff being conducted up into the open air, so that in case of a regulator failing to shut off properly, the pressure will blow the seal and the gas will be blown out. The blowoff tank should be made large, so that there will be no danger of the escaping gas carrying out the oil and permanently unsealing it, a tank for a 6″



blowoff being cylindrical in shape, about 3 ft. 6″ in diameter and 4 ft. 6″ deep. They may be made of heavy galvanized iron, the inlet pipe for the seal being carried down through the top to within about 4″ of the bottom. A set of gauge cocks or a water gauge glass may be put at the side of the tank so that at any time the depth of the oil or the sealing fluid may be ascertained. It is customary to carry about enough seal so that a tank will blow at from 10 to 12 ounces.

50. *Size of Services.* On account of the increased consumption of fuel gas at the present time, services for low pressure artificial gas plants are laid of much larger sizes than formerly. Almost all gas companies now use 1¼″ wrought iron pipe, some 1½″ exclusively, and very few less than 1″ size for a service into the ordinary sized dwelling. The larger size pipe does not cost much more, is stiffer, and there is much less liability to trap or become obstructed in any way.

51. *Manifolding Services.* The best practice is to put a separate service from the curb into each house. In case two



houses are on the same lot, one in the rear, a branch may be taken for the first house and the service continued to the second, provided the tap is large enough to carry two houses and all parties agree.—(O. Q. B.—'06—No. 586.)

In conditions that do not admit of more than one cut across the street, two or three services may be manifolded as per sketch, in which case the service across the street will, of course, be made large enough to supply all three consumers. It must be remembered, however, that a consumer is always better satisfied and less liable to complain of poor service if he has an independent connection.

52. *Service Gang and Tools.* The service work is usually performed by a gang of men consisting of one or two fitters and three or six laborers under the direction of a foreman. On account of the time consumed going to the shop it is better to cut the pipe and do the fitting right on the job, and it has been found advisable to equip them with a wagon containing a portable bench and vise, also tools for cutting the pipe, some lengths of pipe and the necessary fittings. The following is the probable equipment of a gang:

3 sharp nose D-handle shovels.
1 long handled shovel for tunnel work.
4 railroad picks with handles.
1 3′ 6″ crow bar.
1 street broom.
1 tapping machine, ¾″ to 2″.
1 12-pound sledge.
2 18″ and 1-24″ Stillson or Trimo wrenches.
1 each 12″ and 15″ Coe wrench.
1 18″ wall chisel.
1 hatchet.
1 wheel pipe cutter for vise use.
1 3-wheel pipe cutter for trench use.
1 set calking tools with hammer for setting up leaky joints.
1 can pipe coating with brush.
1 stock with dies for vise use.
1 ratchet stock and dies for trench and repair use.
1 18″ bastard file.

1 iron oil can with oil for same.
3 lanterns with red globes with oil for same.
1 small test pump with gauge.
1 2-pound machinist hammer.

In case a bench is not carried, the vise may be arranged so as to be clamped to a telegraph pole with a chain in the same manner as the tapping machine is clamped to the pipe. Some companies prefer push carts to wagons, in which case the vise is clamped to the tail of the cart which is so arranged that when straightened up it can be blocked to make the vise available. "Where mains are laid at a standard distance out from the curb, and a curb cock is used, stop lengths, that is, lengths from the main to cock can be with advantage, made up in the shop and sent out with a stop cock on." (Walton Forstall—'06—O. Q. B.—No. 476.)

Otherwise it is not considered practicable to equip a service gang with cut lengths of pipe.

53. *Service Records and Orders.* It is important that a complete record be kept of every service run. For this reason the foreman should be given a written order for each service. On the face of this order he should be given such information as would enable him to do the work intelligently. On the back of the order should be provided means by which he might readily make a sketch showing the location of the service with reference to the house and the street, mark the distances and give a memoranda of the pipe and the fittings used. The data on these orders when turned in by the foreman should be entered by some person either on cards or in a book kept for that purpose.

54. *Connecting Services to Small Mains.* The use of large size services render it impracticable to tap the smaller size mains. For this reason it is customary with a large number of gas companies to insert tees in whatever 2″ main they lay wherever a service may be expected. These tees are inserted when the main line is laid. Even if a 2″ main line could be tapped, the end of the service fitting when screwed into the main, would project so far inside the main as to seriously obstruct the flow. (Doherty—Simpson—'04—Q. B.—No. 103.)

For this reason where a service connection is to be made to either a 2″ or 3″ line where no tee has been inserted, it is preferable to make the connection by means of a saddle, drilling the hole in the main at least one size smaller than the service to be laid. In making a connection by means of a saddle, either lead, rubber, leather or white lead may be used to make the joint between the saddle and the main. Soft lead is preferred. If rubber is used it should be noted that the washer should not be very thick, otherwise it will soften and in time squeeze out from between the joint and obstruct the service. ('04—Q. B.—No. 103.)

If, however, the connection to either a 2″ or 3″ line is larger than 1¼″ it is better to cut the line and insert a tee, using either the ordinary style of tee with nipple and long thread or else insert a Dresser or Hammon tee. (Stone—Hellen—'04 —Q. B.—No. 103.)

Sometimes in tapping smaller size mains a split sleeve is used which is calked on the main. Afterward the opening is tapped through the sleeve.

55. *Using Swing Joints.* There has been much discussion as to whether it were advisable to use a swing joint in making connection to a main, or whether the connection should be made straight, but the best authorities approve the swing joint. In making a swing joint the opening at the main is tapped on top, and at least one size smaller than the service to be run; for instance, for a 1¼″ service, a 1″ or ¾″ tap may be made, the jet discharge being sufficient to fill the pipe. A reducing tee is then screwed into the main, then a street ell into the side of the tee making a swing. The top opening of the tee is used to insert a wooden or rubber plug to cut off the gas while the service is being run. This makes the operation safe while the work is still in progress, relieves the pipe of both vertical and horizontal strain due to settling or crawling, and makes it very much easier to renew or enlarge the service. (Walton Forstall—Frank Hellen—Simpson—'03—Q. B.—No. 128.)

56. *Making Straight Connections.* Some authorities object to tapping on top and using a swing for the following reasons:

Too easy to become obstructed, too liable to sag, and if a trap should occur in the service, it cannot be cleaned out thoroughly, and the service does not admit of being well blocked. These same authorities say that where the main is very deep a bend screwed into the top of the main should be used to bring the service to the desired elevation. Undoubtedly the fittings used in tapping on top and making the swing might cause an obstruction to the flow of gas unless of an ample size, but in six cases out of ten breaks occur where the service is screwed into the main and the use of the swing joint in allowing for expansion and contraction, makes breakage much less frequent, and there is no reason why the swing joint should interfere with the proper blocking of the service. It is thought advisable when a man is tapping for a service connection into a main that some other employee should be near to assist him in case of accident, and it is further suggested that where the ordinary tap is used, the use of soap on the tap will largely prevent the escape of gas. In no case should a union be used to make a connection between a service and main unless the union is fitted with a lead washer; otherwise, the washer is liable to shrink and the connection become leaky.

57. *Grade of Services.* The minimum grade to which service should be laid is about 6″ to 100 ft., and in case this minimum grade is used, great care should be exercised in laying the pipe. The ditch should either be carefully bottomed up or the service blocked, so as to insure that there will be no settlement. ('03—Q. B.—No. 110, and '04 Q. B.—No. 120.)

58. *Depth of Services.* No definite depth can be prescribed for laying services. They should be laid, if possible, below the frost line, and also deep enough to avoid any trouble caused by the jar or vibration of traffic on the street. Usually two or three feet deep is considered sufficient. (Simpson—Frank Hellen—Shelton—'04 Q. B.—No. 105.)

59. *Stop Cocks at Curb.* The increased use of larger sizes has made most gas companies favor putting a stop cock on the service line at the curb, and in case of very large sizes, 2″ and

over, when a number of meters are attached to the same service, it is considered by some gas companies good practice to put an additional stop cock just inside the cellar wall. ('06—Q. B.—No. 493.)

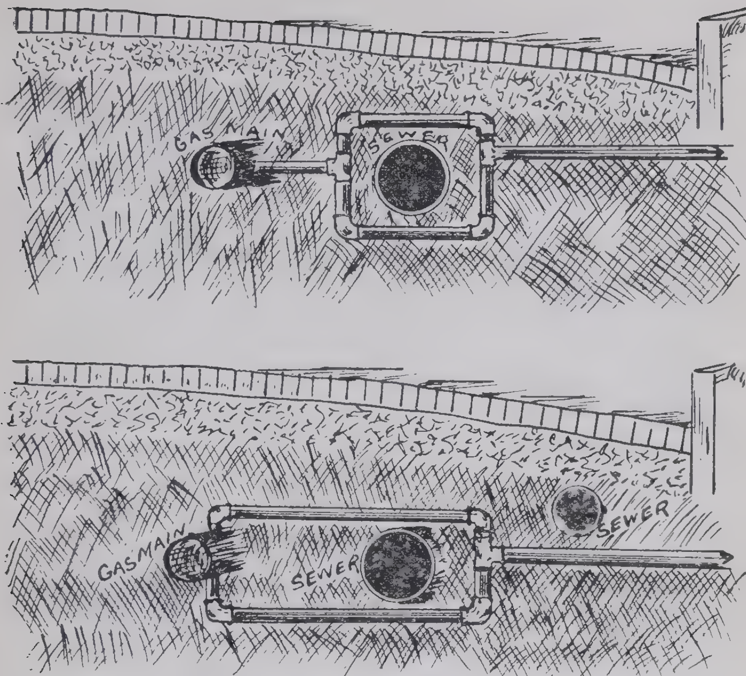
The stop cock at the curb is preferably an all brass cock, and in order to avoid any breakage or leakage caused by strain, it should be extra heavy, the average weight of a 1¼" cock now used being about 3 pounds. A cock having a cast iron body and brass plug is liable to break. ('06—Q. B.—No. 477.)

It has been urged as an objection against stop cocks at the curb that the box is liable to be filled up or get out of place, so that in case it is found necessary to get at the stop cock to shut it off or turn it on, the employees can not do so, and it must be dug up. While this objection may hold good, yet out of the total number of stop cocks in use, a very small proportion of them will be found in such condition that they can not be used when needed. (Young—W. G. A.—'92.)

60. *Getting Around Obstructions.* In case an obstruction is encountered which will not allow the service to be laid and have the proper fall, the service may be looped around the obstruction, the upper pipe of the loop supplying the gas, the lower one taking care of the condensation. (O. Q. B.—'05.—No. 572.)—See illustration on opposite page.

61. *Service Fitting in Cellar.* It is good practice to put a tee on the end of the service which projects through the cellar wall, the side opening of the tee being used to continue the pipe for the meter connection—the end of the tee opposite the service is reduced to ¾" and plugged. In case of trouble this plug can be removed to admit connection being made to obtain the pressure or remove obstruction from the service, or if the service is frozen, a ¾" street elbow screwed into the opening enables alcohol to be poured into the service to thaw it out. ('06—Q. B.—No. 530.)

An old service that has been disconnected or unused for some time should not be connected up or the gas turned into it until it has been tested with a pump and gauge, as it may be rusted or broken and leak.



Avoiding Obstructions in Service Laying

62. *Coating Service Pipe.* A number of gas companies make a practice of coating the service to prevent corrosion and also to minimize as far as possible the effects of electrolysis. It is doubtful in the minds of some whether the increased protection is really worth the cost, at least on unpaved streets. It must be borne in mind that a coating, to be effective, must be perfect, that is, it must be free from cracks and must adhere to and form a close contact with the metal of the pipe at all points, otherwise corrosion will take place at the defective places and eventually destroy the value of the coating. For specifications regarding coatings for pipe, see the section under "Coatings for the Protection of Main Lines." Sometimes when a prospective consumer does not wish his lawn dug up, or where a paved street is to be crossed, the service pipe is driven from the house cellar to the main, a coupling, then

nipple and cap being used to drive on and a 4 x 4 oak block about 12″ long as a cushion for the sledge to hit. A pipe forcing jack may also be used. In some soils a dirt augur is used with success—if procured the same size as the pipe it will permit the pipe to pass through the hole without serious binding. The augur is screwed on the end of the length of pipe, and the boring is done by turning with a wrench. If a piece of pipe is split in the process, it can be removed and a new one substituted. Either of these methods will possibly work in the right kind of soil where there are no obstructions to be encountered and where plenty of fall can be obtained.

The disadvantages of these methods are, you are never sure of results—never certain that the pipe will either come out where you expect it or have the proper fall. It is also impossible to coat pipe which is put in by these methods. Undoubtedly the best and safest way is to dig the ditch ('05—Q. B.—No. 572.)

63. *Refilling Service Trenches.* A piece of canvas may be put on a lawn along the trench, and if the sod is well taken taken care of and the dirt from the trench thrown out on the canvas, there is no reason that the man cannot fill in the trench and replace the sod in such a way that no offense will be found. If a hole has been cut in the cellar wall, it should be carefully filled up and restored to its original condition. Gas companies will find that it pays to do this work in first class shape, and leave the street and consumers' premises in as good condition as found. Care should be taken in refilling around service pipes that only clean, clay earth or sand is used. Ashes should be especially avoided, as such are apt to corrode the pipe.

64. *Protecting Services from Frost.* Service pipes seem to be particularly subject to trouble from frost. When it is suspected that such trouble will occur, the pipe connection may be laid in the center of a wooden box or tube large enough to form an open air space around it with the ends cemented or closed, this covering to extend from the inside of the cellar wall outward, and in no case should the service

be allowed to come in contact with stone or brick. (Elbert—Progressive Age—July 15, '05.)

Where a service pipe passes through an open area-way in entering a building, it is doubly exposed to deposits and freezing, and straw wrappings or boxing are often resorted to. Another method of minimizing the trouble is by making the line through this dangerous section of extra size, connected to the service proper and to the riser by reduced couplings eccentrically tapped and attached at the upper side of the circle, to permit the lower portion of the enlarged pipe to fill up while still leaving a gas way at the top. The editor prefers to employ an inner tube in the enlarged section, open at each end and centered in the larger pipe by a "spider" or similar support, while the outer pipe extends well within the area and foundation walls at either end, for complete protection. This permits the anulus between the pipes to fill up completely with frost or ice, and such a deposit is an excellent insulation from the further effect from cold. One manager who has employed this method writes that a service which had previously required the daily application of alcohol, went through a severe winter after installing this device, without attention. Another method to prevent frozen pipes is given as follows: "We have put into use the 'lime bucket' to dry the gas so that it will not freeze in cold places like livery stables, freight depots, etc. I do not know how many gas companies use them, or how new they are, but they are a good thing. We use a galvanized half bushel for the average customer using 4,000 cu. feet to 5,000 cu. feet per month. Tap the bucket on the side close to the bottom, and insert a 1″ pipe which extends across the bucket and is soldered in place. This pipe is perforated on the sides its entire length (inside the bucket), thus distributing the gas equally all over the bottom of the pail. Then put in just enough excelsior to cover the pipe and prevent its stopping up and to better distribute the gas. Then fill about half or two-thirds full of good quick slacking lime (small lumps) and solder in the lid, into which is inserted a 1″ nipple, to which is screwed the inlet connection of the meter. For larger customers use larger buckets and more lime. We have one or two in use made from large-sized garbage cans. The cost of the lime

box is trifling when compared with the cost of taking care of places that freeze up as fast as you thaw them out, to say nothing of annoyance to customers and loss of business to the gas company." (W. R. Goudy—Progressive Age—April 15, 1905.

65. *Fittings for Service Work.* In ordering fittings for service work, it is well to order the best malleable iron fittings and some companies prefer them to be galvanized, as the galvanizing has a tendency to close up any sand holes or porous spots in the fitting. An elbow having one end male and the other end a female thread is designated as a street elbow. The same rule applies to tees. In ordering reducing fittings of this character the size of the female end is always

Fig. 1.

Fig. 2.

Fig. 3

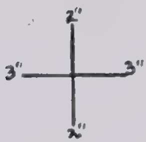


Fig. 4.

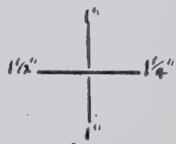


Fig. 5.

given first. Thus a street elbow ordered 1¼" x 1" will have a 1¼" female end and 1" male. "In ordering the ordinary reducing elbows, the larger size is given first, but in ordering reducing tees, it becomes necessary to name the run and the outlet. Fig. 1. illustrates diagrammatically the run and outlet and shows the tee reducing on the outlet. Such a tee is read 2 x 1½". The run is read first. In ordering tees that reduce on the run we say 2 x 1½ x 1¼", as shown in Fig 2. Whenever both ends of the run are of the same size, but having the outlet larger, such a tee is called bull-head and is read 1½ x 2" as shown in Fig. 3.

It will be seen that when a tee reduces on the run, we will have three figures to specify; whereas, if a tee reduces on the outlet, we have but two figures to indicate. Thus in tees

reducing on the run, we have 1 x $\frac{3}{4}''$. In like manner, in ordering crosses, we must be particular about stating the size of the outlet or run. A very important rule about crosses is as follows: The outlets of the cross are always of the same size and indicated by the last figures. By referring to Fig. 4, it will be seen that the outlets are 2″, while the run is 3″, but, since the outlets of a cross are always of the same size, it follows that a reducing cross must reduce on the run. A cross $1\frac{1}{2}''$ x $1\frac{1}{4}''$ x 1 shows the outlets are 1″ while the run is $1\frac{1}{2}''$ x $1\frac{1}{4}''$. It should be remembered that crosses are read on the run first, and, when reducing on the run, we have three figures to mention; when reducing on the outlets, we have two figures to indicate." (Q. B.—E. C. Jones—Pro. Age.—Oct. 16, '05.)

66. *Connecting Meters.* At the present day it is the custom of almost all gas companies to test their meters when they come from the factory or to test any meter which comes into the shop before being re-set. Meters should not only be tested for accuracy but they should also be tested for capacity and smoothness of working. After being tested the inlet and the outlet of the meters should be closed, either by a cork or a metal cap made for that purpose which is screwed over the threads. This will prevent the air from entering the meter and drying out the diaphragms. They should also be set upright on a shelf, face outward, so as to be readily accessible. Some gas companies give each meter a shop number or a company number when the test is made. This number being stenciled in brass and soldered on the meter. In connection with the maker's number it provides a ready means for identification.

67. *Orders for Meter Setting.* While a few gas companies use iron meters, the large proportion of meters used are of the ordinary type of tin meter; consequently we will deal with the handling and setting of that kind of meter. All orders for the setting of meters should be given from the office of the company to the foreman having charge of that department. The order should state, if possible, the size and style of meter to be set, the location, and whether it is a re-setting or an

entirely new job. In the larger cities these orders are taken by a foreman and the orders for a certain district bunched together to facilitate the working. In this case it is customary to use a wagon on which a number of meters can be loaded at once; this wagon also carries an equipment of tools, some pipe and fittings. In the smaller towns the order is probably given to the individual fitter, who takes the meter out with him, measures up the job and returns to the shop to cut out his pipe and make up his connections.

68. *Handling Gas Meters.* At all times meters should be carefully handled. They should be kept right side up. If carried in a wagon, each meter should be placed in a padded compartment for that purpose, and the wagon should have easy springs to prevent jolting. Meters should not be thrown, bumped across each other, jarred or mistreated in any way It is a fact that improper registration is largely caused by the careless handling of the meter, the valves being jarred from their seats and failing to seat themselves properly. Careless handling, too, may break the glass in front of the meter dial. It may dinge the meter, causing it to appear unsightly and giving it a scrap heap appearance. In case the paint is rubbed off or marred, a place is made which is readily rusted through, thereby shortening greatly the life of the meter. (O. Q. B.—No. 473—1906.)

69. *Lead vs. Iron Connections.* There has been much discussion as to whether it were advisable to connect tin meters by the use of either lead or iron meter connections. The advocates of lead connections make the point that a lead connection is more easily made, as the lead pipe can be bent into position, and that there is less strain on the meter, because if there should be any pulling of the pipe, the lead will give a little. They also say that a meter should never be supported by the connections, and for this reason the use of a shelf, which is necessary in case lead connections are made, is no objection to their use.

70. *Lead Connections.* Where meters are connected in this manner, it is customary to keep a stock of lead pieces already

made up. These pieces are of two styles: in the one style the meter swivel is inserted directly into the end of the lead pipe, thus making a straight connection. In the other style the swivel is inserted in the side of the pipe, making a right angle or what is termed a "shoe connection."

It is better to insert the swivel in the end of the lead pipe, making what may be called a straight connection, rather than to insert it in an opening cut in the side of the pipe, making a "shoe connection," as it is sometimes called, for this reason: the straight connection is much stronger than the "shoe connection." This follows from their respective methods of construction. The swivel, when inserted in the end, is fastened to the pipe and held by it along a much greater length than when it is inserted through the side; consequently it is held more firmly, and is able to stand a greater strain, without breaking the joint and causing a leak.

The swivel being simply a continuation of the pipe, the straight connection affords a freer passage for the gas. Unless the "shoe connection" is very carefully made the swivel is apt to be pushed so far into the pipe that it seriously obstructs the passage of the gas even when it is not intentionally pushed far in to secure greater strength. If the hole in the pipe is not cut to the proper size and shape there is also danger of solder running down into the pipe and partially blocking it. The tight fit between the pipe and the swivel in the straight connection prevents any such running down of solder into the pipe. Any obstruction, whether caused by the swivel or by solder, has a tendency to give rise to a deposit of naphthalene in the connection. Even if perfectly made the shoe connection causes the gas to change the direction of its travel very abruptly, and thus throws more pressure than the straight connection, in which the change in direction is never more sudden than that caused by the use of an ell. "Aside from these excellent reasons the straight connection costs less to make."—Mastin Simpson.

One claim that is made for the "shoe connection" is that it is very convenient when meters have to be set close to the ceiling, but even in such cases it is possible to make the

connection in other ways that are stronger and more workman-like." (A. G. L. A.—1901.)

71. *Iron and Lead Connections.* "Meters are sometimes set with one iron and one lead connection. The iron connection being used on the inlet gives greater stability for turning the cock and helps support the meter. The lead connection on the outlet gives flexibility, and by allowing for the variation in the width of meters makes it easier for the fitter to make the connection."—Mastin Simpson.

72. *Iron Pipe Connections.* Iron pipe connections for meters are becoming more and more used. The great objection to them has always been that they were very rigid, and any jar or shock to the pipe or any strain on the pipe was apt to cause a leak at the meter connection. This has been recognized and has largely been provided for by making the meters stronger where the screw is attached to the case of the meter. Almost any manufacturer now will sell meters with long screws which are riveted to the case, at a very little, or if any, greater cost than the ordinary type of meter. The use of these long screws makes it practically impossible to pull the screw away from the meter case without tearing the meter apart. In setting a meter, too, this strain is compensated for by the use of a double swing on at least one connection of the meter and a single swing on the other side. These swings may be formed by using an elbow and two street ells, or by the use of a special fitting made for that purpose.

If correct measurements are made for the connections and the swing is used and the inlet and outlet pipes are properly fastened, (for this, string or rope should not be used but wire hooks, made for the purpose, are best), so that there is no strain on the meter, except its own weight hanging on the connections, there is practically no danger in using iron pipe connections. Among the advantages of this style of connections are the following: That they cost less than lead connections; that they require no shelf; that if properly set up, the meter will stay plumb; that the connections are not so liable to be stolen; that an incompetent fitter can not kink the pipe which is so often the case in making a lead connection,

thus obstructing the flow, and that, in case a meter is taken out, it is easier to re-set another meter. (O. Q. B.—No. 121—1904.)

As a comment on the above advantages, it might be said that an incompetent fitter should never be employed on meter work. An incompetent, careless man, by making a leaky or faulty connection, can make more trouble and cause more damage than his wages for a year will amount to.

73. *Location of Meter.* It is assumed that when the service foreman runs the service into the building he takes into consideration the probable location of the meter, as it is desirable that a meter be located as near as possible to where the service enters the building. Greater attention than is usually the case should be paid to the location of the meter. It should be placed where it is readily accessible, not in a locked room or closet, as in this case the meter reader would spend a great deal of time looking for the key. It should not be placed in the coal bin as it might be struck by some of the coal and become damaged and the coal might be piled in front of it to such extent that it is almost impossible for the meter reader to see it. It should be so placed that the meter reader can read it readily. It must be remembered that the meter reader will visit the meter frequently and if it is in a position difficult to read, he is liable to make mistakes. The meter should be set in a place having as near an even temperature as possible. If exposed to extreme cold a greater amount of condensation will occur in the meter, the valves are liable to become gummed and stick, causing improper registration, and if subject to freezing weather the leather diaphragm will stiffen up and have a tendency to crack. On the other hand, if placed in too warm a place, the heat will dry the oil from the diaphragms causing them to become stiff. (O. Q. B.—No. 115—1904.)

Meters should be put as near the ceiling as possible. They are more out of the way there and there is no probability then of them being turned upside down to unseat the valves. In ordinary cases it is advisable to place all of the meters for one building in one place, running separate risers from this one

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place to different parts of the building. Where meters are set in this manner they are usually set in a row, the supply pipe coming up at one end or possibly in the middle, running over the tops of the meters and making a header from which the separate supply for each meter is taken. It is advisable in making the header to space the meters in such a way that a larger size can be substituted if desired. In placing meters in a block, it is sometimes desirable that all of the meters for each floor should be placed on that floor. In this case a main riser is run up, a branch taken off at each floor and the meter placed in a meter room or closet on that floor.

74. *Testing for Leaks.* It is important that the meter setter be given instruction that the pipe in the building should be carefully tested before setting a meter or before re-setting, and that under no circumstances will a meter be connected and the gas turned on until the pipe in the building is made perfectly tight. After the meter has been connected and the gas turned on, the meter setter should proceed to see that the supply is all right by lighting the various fixtures and seeing that they burn properly. He should stay long enough to see that all of the air is blown out of the meter and piping, otherwise complaint may come to the office that there is no supply; after which he should, with soap and water, test the meter connections for leaks. Under no circumstances should a light be used for testing for leaks around the meter, for if the leak were a large one an explosion might occur, and if the leak were a small one, and near the meter connection, it might light and burn without being noticed by the fitter, but would eventually melt the solder, causing the connection to part from the meter, resulting in considerable damage.

75. *Prepayment Meters.* In general, prepayment meters are so located as to be accessible only to the consumer for whom the meter has been set. This makes the consumer feel a responsibility for the meter, and there is less likelihood of its being tampered with, and in case it is tampered with it is easier to fix the responsibility. It is also advisable to set these meters in a position where it is comparatively easy for the consumers to get to them and insert the coin. They

should not be set where they are accessible from the street, as this would make it easy for some one to break open the box and extract the money. It is doubtful whether it is advisable to set meters of this kind for hotels or rooming houses, as there is danger of the meter shutting off, causing the extinguishment of the light or fire, and afterwards one of the boarders or roomers drops a coin in the meter, causing it to start running again and the escaping gas from the outlet, which has been extinguished, asphyxiating the occupants of the building.

76. *Meter Cock Seals.* Meter cock seals are now placed on the market. These are used by some gas companies, and instead of taking the meter out when a consumer discontinues using the gas or moves from the premises, the stop cock of the meter is sealed in such a way that no gas can be used by an incoming tenant until the gas company has been notified and a man has been sent from the office to break the seal. This, of course, is much less labor than taking the meter out and setting it again.

77. *Leakage of Gas.* Leakage of gas is a problem confronted by all gas companies, and one which every gas company is anxious to remedy as far as possible, as the loss of the gas entails a loss of money. In addition to this, there is the damage to trees and vegetation, the danger of explosion, the unpleasant smell, causing discomfort and annoyance to the residents of the city, and it has been claimed that gas leakage will soften asphalt pavement, but the claim does not seem well founded. Simpson, '03 Q. B., No. 102, says: "I have found considerable softening of asphalt over ditches, but I could never trace it to the gas itself, although there were frequently leaks under such abrasion, but I have found exactly the same conditions over sewer trench and water mains, and my belief is that the softening is due entirely to the working of the ground under heavy traffic over the ditches. For six months of time we hung in a jet of impinging gas a piece of asphalt, and as far as strength of texture was concerned, we could find no difference after the test."

Baehr, '03—Q. B.—No. 102, says: "When there were gas

leaks in the mains caused mostly by the proximity to steam heating pipes, the concrete under the asphalt became saturated with gas getting to be of a bluish color. The asphalt itself disintegrated slowly under the same influence, and became soft and smelt strongly of gas. The evidence was unmistakable." In this instance the writer's opinion, however, is that the softening of the asphalt was due to the steam heating pipes and not to the effect of the gas.

"If due care were taken and conditions were perfect, there would undoubtedly be no leakage from mains and services, as it is possible to lay both cast and wrought iron pipes and have the system bottle tight." (Walton Forstall and Shattuck—'04—Q. B.—No. 103.)

78. *Computing Gas Leakage.* I have never seen any attempt to compute the loss of gas per mile of service. Leakage is often affected more by the station meter than by the efficiency of the street men. It is generally conceded good practice if leakage does not exceed 100,000 cubic feet of gas per year per mile of main reduced to a 3″ basis. In reducing mains to a common basis for estimating leakage, the ratio is directly as the circumference of the pipe, because the area for probable leakage will be the outside of the pipe and the joint surface. As the circumference and the diameter are in the same ratio it is easier to use the diameter for figuring ; for instance, a 6″ pipe will have twice the leakage area that a 3″ has and one-half as much as a 12″.

Example—for relative leakage :

100 ft. 6″ pipe equals 200 ft. 3″.
100 ft. 12″ pipe equals 400 ft. 3″.

Almost all gas companies now make periodical tests of their mains and services to determine leakage.

79. *Testing by Districts.* If a thorough testing and overhauling of the distribution system is to be made, the city or town should be divided up into districts, and each district isolated, if possible, and gas passed into each section thus isolated through a meter, the consumers' meters in such section being all shut off. In this case the consumers must

have due notice of both the shutting off and turning on again, and the gas should not be turned on without the consumers' knowledge or access to the fixtures. If the registration of the testing meter shows an abnormal leakage, barring should be resorted to to locate the leaks. In a section where it is impracticable to shut off the consumers so that the section may be tested by allowing what gas leaks to pass through a test meter, and if the leakage is known to be great, it will pay to bar over all of the mains.

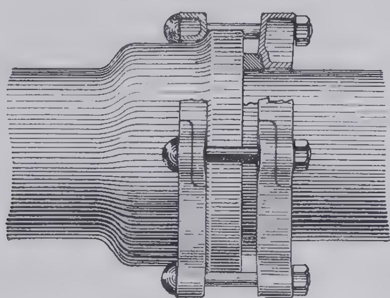
80. *Methods of Isolating Sections.* There are several ways of isolating a section ; if valves are already in place and are tight, these valves may be shut off ; if the valves are not tight and are double gate valves, the valve may be washed clean by flushing with water through a 3/8" hole drilled in the side of the valve between the gates. If this does not make them tight the valves should be closed and a street ell screwed into the 3/8" hole. From this street ell a pipe is extended upward 2 or 3 feet, and the space in the valve between the gates kept filled with water or oil. Another plan which may be used when valves are not available is to tap a 2" hole in the main and insert 2 bags into the pipe, inflating them equally and making them take position on either side of the bag hole. A 2" nipple some 2 or 3" long is slid down over the tubes of the bags and screwed into the hole. Water is then poured into this nipple, and fills the space between the bags to supplement their own tightness. By keeping the water filled up into the nipple, a slight head is maintained, and a most satisfactory degree of tightness is secured. If the mains on which the bags are used contain deposits of naphthalene, a wise precaution is to wash it out by injecting naphtha or wood alcohol through the bag hole, followed by a thorough washing with warm water. Should the water leak from between the bags very rapidly, a heavy oil may be used instead of water, or the water may be mixed with oatmeal. Another method of sealing is to tap a very large hole and fill the pipe with a mixture of fire-clay and cement, half and half. This mixture will not set hard, and can be removed with a spoon after the test has been completed. In this case, as well as in the case of a smaller

main where a large hole is tapped for the insertion of the bag, a sleeve should be put around the main at this point to strengthen it when the test is completed.

81. *Barring for Leaks.* In barring or sounding for leaks, it is well to locate the position of the main as near as possible and drive the bar down at the side of the main and to the depth of about the bottom of the main. If the joints can be located, so much the better, and the bars should be driven near the joints. If one joint is uncovered, the location of the other joints may be measured off by using that joint as a basis. Different methods are used for barring. Some gas companies use a hexagon steel bar ⅞" in diameter and about 6 feet long, pointed at one end. This bar is driven into the ground by its own weight, the man using it, lifting it up and driving it into the ground with both hands somewhat in the same manner as he would a spear. The bar will usually sink from 2 to 6 inches at a stroke. After the first stroke, the bar is worked around slightly, then lifted and dropped into the hole again. This operation is repeated until the required depth has been reached. This method works particularly well in soft ground. In ground which is harder, a bar about 5 feet long and 1⅛" in diameter is used. This is driven into the ground by using a 6 or 8 pound long handled driving hammer. If the ground is very hard, a shorter bar, of larger diameter, say 3 feet long, may be used to start the hole. In sounding, care should be taken, especially where the sledge or hammer is used, that the bar is not driven through the main. If a bar sticks tightly, it may be pulled by means of a lever and chain. The chain wrapped around the bar and then hooked up over the end of the lever and by placing a fulcrum under the lever and then bearing down on the long end, the chain will tighten and the bar may be pulled. After the hole has reached the required depth, the sounders should smell to determine if gas is escaping. It should be tested again in about 10 minutes. If a leak exists, it will be evident by this time. Stale gas will not last and may be detected by the sourness of the smell. Should 3 or 4 adjacent holes smell, allow them to remain open for some time and dig up the one which finally shows the

largest amount of gas escaping. If there is no leak detected, the hole may be closed up. In closing the bar holes in pavement, the earth should be tamped in to within six or eight inches of the top, and the hole then poured full of a grout made of neat cement.

82. *Repairing Leaky Cast Iron Mains.* When the leaky main or service has been uncovered, the cause of the leak may be ascertained, and a remedy should be applied which would be a permanent one. In case it is just simply a lead joint which leaks, it may be re-calked. If, however, examination would convince the foreman that the leaky joint is caused by vibration of the pipe caused by heavy traffic on the street, the joint must not only be re-calked, but, in order to be a permanent job, a leak clamp as shown in the figure below, should be placed on the joint.



The rubber on these clamps allows for a certain amount of vibration. The same method should be pursued in case of a leaky cement joint with this exception: that in the case of a cement joint, the first string of yarn should be entirely cut out and the joint should be made all over. A leak which is too small to light may sometimes be detected by the condition of the soil around the joint, in such cases it being usually blue or blackish in color. The men should be cautioned not to use a light when looking for leaks but to depend on the sense of smell or soap and water. The flash from a light may travel for some distance and acting as a fuse to a body of mixed gas and air, cause an explosion, resulting in great damage. If a main is broken the escape of gas may be

stopped temporarily by putting either clay or soap into the crack. If the main must be left for some time without being permanently repaired, a temporary repair may be made by wrapping canvas or muslin saturated with white or red lead, around the main. If the break runs around the pipe and does not extend longitudinally, the repair may be made by a split sleeve. If the crack extends for some length along the main, the piece must be cut out and a new piece inserted. When a split sleeve is to be used, all dirt and rust must be scraped off the pipe for a distance of a foot on each side of the break, and if the pipe has settled it must be brought back to the proper grade and alignment. A strip of unbleached muslin, wide enough to cover the break with a margin of three or four inches on each side and long enough to completely wind around the pipe several times, is smeared with a putty made of white lead, or equal parts of white and red lead, and linseed oil, and wrapped tightly around the pipe over the break. This serves to entirely prevent the escape of gas while the job is being completed. A split sleeve, that is, a sleeve made in two pieces, each of them similar in size and shape to the pieces that would be obtained by splitting a solid sleeve along a plane containing both its axis and diameter and provided with longitudinal flanges by which they can be bolted together, is then applied so as to cover the pipe at the break and for at least three or four inches on each side of it. The joint between the split sleeve and the pipe can be satisfactorily made in various ways.

One method is to plaster the inside of each half of the sleeve with a layer of Portland cement, mixed neat, of sufficient thickness to insure the complete filling of the joint and the compacting of the cement without allowing the flanges to come face to face when the two parts are put over the pipe and drawn together by means of the bolts. Enough cement should squeeze out through the spaces between the flanges to fill them thoroughly; but if this does not occur the unfilled places can be pointed up, so that, when the job is completed and the cement has set, the two halves of the sleeve are joined together with a gas tight joint by the cement between the flanges.

Another method is to make the joints between the flanges gas tight by using strips of millboard that have been soaked in hot water until they have become soft enough to be squeezed into all the roughness of the faces of the flanges when the two halves of the sleeve are put in place, surrounding the pipe, and bolted together. The joint between the sleeve and the pipe is then made exactly as would be done in the case of a solid sleeve, using either lead or cement. The latter is preferable, unless the conditions are very much against its use, since making lead joints involves the carrying to every repair job of a furnace, lead-pot and ladle. Drawings of two styles of split sleeves, showing their dimensions and the number of bolts used, can be found in the Proceedings of the American Gas Light Association, Vol. XV., page 68, and page xiv. of the Appendix and also in the American Gas Light Journal, Vol. LXIX., page 712, and Progressive Age, Vol. XVI., page 529.

When the break runs too far along the pipe to be properly covered by a split sleeve, it is necessary to cut out the damaged portion of the pipe, making the cuts at least 3″ to 4″ beyond the furthest point reached by the crack at each end, and replace it by a new piece. To do this, the main must be uncovered for a sufficient distance to enable bag holes of the proper size to be drilled and tapped far enough apart not to interfere with the work of putting in the new piece. The gas having been shut off by means of the bags inserted in these holes, the pipe is cut at the proper points, either with a pipe cutter or by the use of a diamond point and cold chisel, and a new piece of pipe of the required length cut and put in, a solid sleeve being used to make the joint where the two spigot ends come together. Before sliding the sleeve into place, the opening between the two spigot ends is covered by wrapping the pipe with unbleached muslin prepared and used as is done in connection with the repair by means of a split sleeve. Either lead or cement joints can be made in the bell and in the sleeve, but the use of cement is generally preferable, for the reasons stated above. (A. G. L. A.)

Should the leak be simply from a sand hole in the main or

because a bar has been driven through it, the hole may be tapped and a plug inserted.

83. *Determining Cause of Corrosion.* If the main should show signs of pitting or of corrosion, it would indicate that either the main is laid in ground which is filled with ashes or some other material the acid of which would affect the pipe, or else it would indicate that the main is subject to the action of electrolysis. If the pitting is caused by electrolysis, the metal will be found to be very soft around the pit marks, resembling carbon, and capable of being cut with either a knife or chisel. There is also a difference in the oxide.

"The difference between the oxide of iron due to cinders, ashes, etc., and that due to electrolysis, can always be determined by drawing a piece of oxide across the unglazed edge of a piece of broken porcelain or across a 'streak' plate used by mineralogists.

"The oxide from electrolysis is always three-quarters oxide —the magnetic oxide (Fe_3O_4), and leaves a black mark or streak. The oxide due to rust, cinders, etc., is always the two-thirds oxide (Fe_2O_3), and leaves a red streak. The three-quarters rust never occurs in the street except through electrolysis." (O. Q. B.—No. 603—J. M. Morehead.)

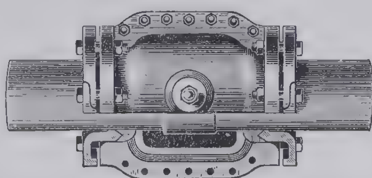
But the surest way of determining is by taking electric measurements with a volt meter. In case it is determined that the leakage is caused by electrolysis, an expert should be called into consultation to determine the best way of minimizing the trouble.

84. *Broken Service Connections.* Oftentimes the main will be found broken where the service connection is made to the main; in this case it is advisable to put on a split sleeve and tap the service connection through the sleeve, connecting up the service again by means of a running thread, and the service should be carefully blocked. If the service is broken off at the main or should be pulled out of the tap hole, the hole should be drilled and tapped a larger size, and the service re-connected. In doing this work, the workmen should be very careful that the service and main are properly blocked before leaving. In case the leak is from a rusty service, the

service pipe would need to be renewed, and if the soil shows signs of the presence of ashes or other corroding material, the service should be protected by an application of one of the coatings enumerated under "Low Pressure Main Laying."

85. *Thawing Out Frozen Ground.* Broken mains usually occur in the winter, and the ground may be thawed out by means of coke fire or, if it is not advisable to use a fire, by digging out the ground to a depth of 3″ or 4″, throwing a barrel of unslacked lime into this hole, throwing some water on the lime and covering with some pieces of old carpet; or burlap or even dirt may be used. The heat from the slack of the lime will thaw out the ground to the depth of a foot or more. It is well to do this in the evening when leaving the job, and allow the lime to stand in the hole all night.

86. *Putting Out a Fire.* If the main is broken and the escaping gas has caught fire by some means, the fire may be extinguished by throwing a quantity of flour upon it. The larger the blaze the greater the quantity of flour needed.



Heavy Split Sleeve.

87. *Vent Pipes for Leaks.* All gas companies should make a practice of overhauling the main line on any street which is about to be paved, and put it in first-class condition, re-calking or repairing any leaks which may be found, and replacing any defective pieces of main. In this connection it has been suggested that when this work is done, it is well to mark on the curb or at least make a record of the location of joints and, in order to facilitate the location of any future leakage, to run a 3¼ vent pipe from the joint to the curb and then up to the service of the ground where it is capped. The idea is, that should a leak develop on the street, by taking off the cap the leak can be readily located, and in that case the leak cannot be repaired at once, the vent pipe may be so

arranged that any escape of gas will come to the open air through it, and that the gas will not permeate the ground and kill adjacent vegetation.

The locating of leaks in wrought iron main lines is not essentially different than that described for the location of leaks in cast iron mains. If the leak is a split in the pipe or a defective weld, it is usually repaired by means of a split sleeve. If it is simply a sand spot in the weld, it can be drilled and tapped out and a plug inserted. If the bad spot is too large to be drilled out and tapped successfully, the leak may be closed by means of a blank saddle clamped tightly over it.

Leaks at joints where the pipe is screwed into the couplings or fittings, may be repaired by means of collar leak clamps. For description of these, see article under Natural Gas Section.

88. *Complaints of Poor Pressure.* Complaints of poor pressure should be investigated at once. The poor pressure may be either local—that is, confined to one consumer—or it may cover a district. First determine, either by inquiry from the consumer, or by investigation, the nature and the location of the trouble. If it is general—that is, if it occurs over all the house—the cause must be in the service, meter, or in the riser between the meter and the first branch pipe. If it is confined to one floor or one room, it is only necessary to examine the portion of the system which supplies that floor or room. Poorness of light, due to a uniform low pressure without fluctuation, indicates an obstruction formed by solid matter. A quick, sharp, jumping flame shows an accumulation of liquid at some point, and a slow rising and falling in the size of the flame, which takes place in comparative long and regular intervals is a sign that the meter is overloaded or else sticks at some point. If the supply is poor in one fixture and good in others, the trouble is not due to poor pressure, but is caused by stoppage in the fixture which can be readily removed. If poor supply in Welsbach lights only, it is usually caused by poor combustion. That is, an improper amount of either air or gas, and the burners should be adjusted in the period of greatest consumption. Complaint of poor supply to gas appliance is often caused by poor combustion due to the

improper size of orifice, which may be either too small or too large, or the trouble may be caused by an accumulation of dirt and dust in the air chamber. (Frank Hellen—'04—Q. B. —No. 114.)

If the trouble does not seem to be in the fixtures, to localize the trouble it is advisable that at the hour of greatest demand a U pressure gauge be placed on an adjacent lamp post, and a reading be taken to see if the pressure on the gauge is normal. If the pressure on the main is normal the gauge is then placed on the service before the inlet to the meter. If, when gas is being used under the usual conditions, the gauge shows a marked drop in pressure between the main and the end of the service at the meter, then the trouble is in the service. The obstruction in the service may be caused by an accumulation of water in the service. This can be readily detected by the intermittent flow of gas as well as by the gurgling noise made by the gas as it bubbles in the water. If water is found, blow it out with a force pump. If the trouble is in the winter time, it may be that the service is obstructed by frost; in that case it can be cleaned by either pouring alcohol into the service or forcing alcohol vapor through the service by means of the force pump.

In using alcohol, gasoline, or other volatile or inflammable liquids for cleaning out stoppages in services or mains, great care should be taken that a light does not come in contact either with the liquid or its vapor. It is best to use a safety lamp in work of this character whenever it is necessary to use a light at all.

"Experiments made in Milwaukee laboratories on a sample of commercial acetone and a sample of wood alcohol on the market, showed the alcohol to be more effective in melting ice than the acetone by the ratio of 1.32 to 1.00, volume for volume. The solvent power for naphthalene at 32° F. was in favor of the acetone by 5.07 to 1.00." (Harrop—'04—Q. B. —No. 126.)

"Our experience demonstrates that grain alcohol is superior to wood alcohol as a solvent for frost, and on account of the smaller quantity needed for the work is as cheap." (Blowers, '04—Q. B.—No. 131.) This seems to indicate that the wood

alcohol on which the conclusion is based was considerably diluted with water. Every purchase should be tested.

Should the trouble be caused by naphthalene, it may be removed by the application of hot water, followed by gasoline and the use of the force pump. If the service is rusted and the stoppage is due to that, a long wire and a force pump may be used for cleaning. If trouble is not located in service, disconnect outlet of the meter, and if trouble is found to exist in the meter, remove it and install another in its place. If the trouble is caused by water in the meter it can be emptied and the meter replaced. In this case the workmen should be careful to empty the meter in some place where the smell will not be offensive. If the trouble is not located in either service or meter, it is usually found in the riser, and if it is not caused by frost, is generally due to an accumulation of rust in one of the elbows which can be readily removed by the use of a wire and force pump. Some do not advocate the use of the U gauge but prefer after reaching the district affected to go from door to door until it is found where the complaint begins. Light all of the burners and go to the house next on each side and do the same thing and note the condition of the lights. "The use of the U gauge is not recommended in running down an order of this character owing to the fact that an employe is often mislead by the fact that if it is a resident section he would have normal pressure registered even if there were only an opening in the main large enough to pass a lead pencil." (Ganser—'04—Q. B.—No. 110.)

This would not occur, however, if the tests were made at the time of greatest consumption. If the first test should show that the main does not carry the normal pressure, then a series of tests should be made throughout the locality and the drop between testing points carefully noted. These tests should be made, if possible, during the period of greatest demand and the readings on the gauges should be taken all about the same time. Calculations of the natural drop due to the friction between these test points should be made. Any discrepancy would denote some stoppage. Partial closure of valves, unpumped drips, flooding of mains, naphthalene, etc. (Latta—'04—Q. B.—No. 110.)

The stoppage will be located between the two points showing the largest difference in pressure. Should a series of tests not show any marked difference of pressure between two adjacent points, but the pressure drop gradually, it is quite possible that the main is not large enough. Should the trouble be caused by a deposit of naphthalene, it may be cleaned out by the application of either steam, hot water, tar-oils or gasoline, as circumstances may indicate best.

89. *Complaints of Leaks in House Piping.* Leaks in house piping and fixtures may not be large enough to make any difference on the consumer's bills and yet be a source of annoyance to him. As before stated, leaks may be prevented by specifying that the best quality of pipe, preferably strictly wrought iron be used, and the heaviest and best malleable fittings, and thoroughly testing the house piping when the work is completed and before the meter is set. The test should be made with an air pump and mercury test gauge. (Kirk, Leach, MacMillan, Franklin, '03 Q. B., No. 125; Cooper, Shattuck, Whysall, Bates, '03 Q. B., No. 135.)

If a leak is reported to the office by a consumer and a man is sent out to locate and remedy it, the following instructions may be given him: Should a leak be in the cellar or be very strong in the house, the gas should be shut off and the windows thrown open to let the accumulated gas escape. The only light used should be a safety lamp. Never search for a leak with a light or match. Use the sense of smell: it is safer and more reliable for the following reasons:

First—Fire may cause explosion.

Second—Flame may discolor any article it approaches.

Third—Odor from flame may prevent later detection of a very small leak by the sense of smell.

Fourth—A small leak, when lighted, burns with a blue flame, which is almost invisible, yet may melt solder joints and ignite other material.

Fifth—A small quantity of gas mixed with air forms a dangerous explosive, hence fire in a leak near concealed piping, or where gas has accumulated, is particularly hazardous. Never permit fire or light in any form in an apartment where

gas is escaping. A current of combustible gas mixed with air will drift some distance from its source and will, when lighted, fire back like a fuse to the main volume, causing explosion.

Always, before repairing or disconnecting any gas pipe or apparatus beyond service or meter cock, take the following precautions:

(a) Notify occupants of all premises supplied that gas will be temporarily shut off, and that all burners in use, including pilot lights, should be at once closed.

(b) Shut off gas completely at cock or valve directly supplying pipe to be disconnected.

(c) When work is finished, notify the occupants of all premises supplied that gas will be turned on, and to assure themselves that all burners remain closed.

(d) Turn on gas at cock or valve which you closed before beginning work.

(e) To determine whether leak exists beyond the meter, assure yourself that all burners, including pilot lights, supplied by meters, are closed. Turn on gas at meter cock. Watch small test hand on meter dial. If hand moves, leak exists. Locate and close leak. Continue this until hand remains absolute stationary during full five minutes.

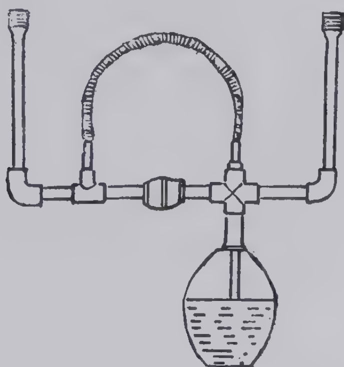
(f) To locate leak, use, first, sense of smell, particularly at pipe joints and fittings. If still doubtful of leak, apply carefully at each joint and fitting strong suds and watch for expanding bubbles indicating leak.

(g) If you cannot locate or cannot close the existing leak, shut off gas completely at the cock or valve directly supplying such leaking pipe or apparatus.

(h) Disconnect one of the side brackets and pour into pipe a small amount of ether. Connect air pump and raise pressure to five pounds. When the fumes of ether will have spread through the whole system of house piping, the location of the leak may be readily detected by the sense of smell. (Frank Hellen, '04—Q. B., No. 109.)

If the gas pressure is to be used for testing leaks, some of which may be so small as not to be detected by watching the meter test dial, the following method (a modification of the original Chollar test by Ferrier) may be used; Bulb shown is a

glass oil cup of the inverted pattern, and is readily obtained from dealers in steam fittings. As these cups are furnished with pipe threads, the ease with which such a device is rigged up is evident. The connection between the cross and the glass tube is made by means of a rubber stopper, and to obtain a tight joint, the threads of that branch of the cross are bored out. The opening of the oil cup must be made at least ⅛″ larger than the external diameter of the glass tube. The



upright nipples shown in the sketch are furnished with the standard male threads of a meter; a set of these nipples corresponding to different sizes of meters should be provided. In making the test, all that is necessary is to substitute the tester for the meter.

90. *Inside Piping.* Almost all architects' specifications now call for the piping in a building to be done according to the rules of the Gas Company, and the Gas Company usually adopts such rules as will insure that the size of the pipe used will be of ample capacity to carry the amount of gas it is expected will be needed with a differential pressure not exceeding ½″ of water. They also specify that the work shall be done in such a manner as to insure, as far as possible, the safety of the occupants of the building. The following rules for the size of pipe for inside piping were adopted by the American Gas Light Association in 1898 :

Diameter Inches.	Length feet.	Gas per hour. Cu. feet.
3/8	20	11
1/2	30	22
3/4	50	60
1	70	127
1 1/4	100	222
1 1/2	150	349
2	200	718
2 1/2	300	1253
3	450	1977
4	600	4059

No greater length of pipe should be used than is given in the table, e. g., the maximum length of 1-inch pipe allowable under any circumstances is 70 feet, and it should not be expected to carry over 127 cubic feet of gas per hour.

One of the Natural Gas Companies where gas is largely used for fuel has adopted the following rules governing the size of the pipe and the method of installation :

GAS FOR LIGHT.

No less pipe than 3/8 inch.

Size of Pipe, inches	Greatest Length Allowed, feet	Greatest No. 3/8 inch Openings Allowed.
3/8	12	2
1/2	30	3
3/4	60	10
1	70	15
1 1/4	100	30
1 1/2	150	60
2	200	100

GAS FOR FUEL.

No pipe less than 1/2 inch.

Size of Pipe	Greatest Length Allowed	Greatest No. 1/2 inch Openings	Instead of 1/2 inch Openings there may be 1/2 and 3/4 or 3/4		
			1/2	and 3/4	or 3/4
1/2	15	1	1		
3/4	50	2	1	1	1
1	70	4	2	1	2
1 1/4	100	8	4	2	4
1 1/2	150	15	6	4	7
2	200	33	14	8	15

All new piping must be tested with a mercury gauge and shall be made tight at a pressure of not less than 4 lbs. or 8 inches of mercury. No Spring gauges will be allowed. The Gas Co. must be notified of the completion of any job so that they may inspect the same should they deem it necessary.

The Riser pipe in any building shall not be less than ¾-inch, and must go up in an inside partition wall and out of reach of frost, and must not project more than 2 inches below the cellar joist. No traps in the riser will be allowed.

Drop or bracket outlets must be securely fastened. Split pipes must not be cemented, but the pipe must be taken out and a perfect piece substituted. No cast iron fittings will be allowed, only the best malleable iron fittings galvanized.

In case more than one consumer wishes to use gas in a building a separate riser must be run for each consumer. In no case will a meter be set where the gas passing through that meter must be deducted from another meter through which it has previously passed.

Piping shall be so arranged that the meter can be placed in a position easy of access and exposed to neither dampness nor extreme heat or cold. The meter should be placed as near where the service enters the building as possible.

Suspended pipe must be securely fastened. No strings, rope or wire should be used.

In addition to the above, the following notes may be of interest.

For this work it is advisable to use the best quality of wrought iron pipe obtainable as this insures that the threads will be cut without stripping and there will be less liability of split pipe. The fittings used are preferably malleable iron, beaded, and the best practice is to use galvanized fittings since the galvanizing has a tendency to fill up whatever sand holes or porous places there might have been in the original casting. For the dope on the threads any one of the various compositions given under "Wrought Iron Main Laying" may be used on male thread only.

Care should be especially taken that all openings are securely fastened. There is now on the market a malleable iron drop fitting having lugs or ears projecting from the side

for the purpose of fastening. The use of this fitting makes it easier to fasten the drop and would also prevent the liability of the drop being unscrewed when the fixtures are taken off. No unions should be allowed to be used as it is almost impossible to make the work come so exact that the two faces of union will press against each other, making a tight joint without the use of a washer, and unions with which the joint is made by a washer are much more liable to become leaky than long screws. The long screws are cheap and make a joint that is tight or as permanently tight as any other joint.

91. *Testing Inside Piping.* After the piping has been completed, it should be tested to see that it is perfectly tight. It is customary for the plumber to first ascertain if his job is tight, and after making sure that this is the case, to ask the Gas Company's inspector to make the final examination. The plumber should see that all openings are carefully closed with caps, and that the foot of the riser line is stopped. Then at any convenient side light attach an ordinary gas fitter's pump and mercury gauge. This mercury gauge should have a column of 15 to 20 inches in length. Air is forced into the piping by means of the pump until the mercury column has been forced up about 10 inches high in the gauge, the pump is shut off. If the mercury falls, there is a leak in the pipe; if it remains stationary, the pipe is tight. It is customary to require that the mercury remain stationary for from 15 minutes to half an hour. If the mercury falls rapidly, it will indicate that there is quite a leak, and this leak will be heard blow. If the leak is caused by a piece of split pipe or split fitting, the pipe or fitting should be removed and a new piece substituted. Gas fitter's cement should not be used for repairing leaks. If the leak can not be heard blowing, ether may be put into the hose of the air pump, and the pumping of the air into the pipes will carry the ether into the pipe. The odor of the ether escaping will indicate where the leak may be found in the pipe, and it may be definitely located by means of a strong soap water applied with a brush or sponge. The liquid is rubbed over suspected joints or fittings, and air bubbles are

blown by the escaping air. In very large work it is advisable to prove one floor or one section at a time and, when all are done, connect them with the riser and prove as a whole. If the pipe to be tested has been previously used for gas, and you have to test for leaks, it will be necessary to take off the meter and cap the bottom of the riser, also to take off the gas fixtures and cap the outlets carefully, as it is impossible to test pipe with the fixtures on and find it tight. The ground joints in the stop cocks of the fixtures almost always leak when the pressure is put on them. Sometimes plumbers, when they have a small leak and are unable to find it or if it is concealed in a partition where it is impossible to get at it to repair, will fill up the house piping with water containing salt or ammonia solution, hoping by this means to rust the leak tight. They are almost always successful in doing this, but the practice should be condemned, as, after the water has been drawn out of the pipe, the ammonia and salt still continue to rust the pipe, and in time this rust will collect in some one place and stop up the system.

Some gas companies require that the gas fitter file at the gas office a sketch or plan showing the size pipes run and the length of each piece. This plan is filed previous to inspection. The gas company's inspector checks up the sizes to see that they comply with the rule. He afterwards examines the piping in the house before it is concealed, and if the piping is according to the rules of the gas company, he gives a certificate to the effect that he has inspected and found it to be tight and to comply with the gas company's specifications. It is stated, however, in the certificate, that the issuing of this certificate does not insure its future soundness. At the time of the setting of the meter or at the time when the gas is turned on, a second inspection is made, this time of both the pipe and the fixtures, and in case these are found tight, the gas is turned on.

F. W. STONE, *Chairman of Section.*
MASTIN SIMPSON.
J. D. SHATTUCK.
GEO. C. HICKS, JR.
HENRY L. DOHERTY.
H. G. STILLSON.

With a general progress report by Dr. H. B. Harrop, Chairman of the Board of Revision, to the first annual meeting of the American Gas Institute, Chicago, 1906.

APPENDIX.

Instructions for Gas Distribution Employes.

GENERAL.

1. Rules serve the same purpose as the pipes used to convey gas; they direct the energy for which the company pays wages and salaries to the point where it will do effective work.

2. It is painfully apparent to the man who thinks that the energy men should give in return for their wages is as volatile as the fluid we make and deliver to our consumers, and that the leakage, or difference between the amount paid for and that actually converted into useful work, is appalling.

3. This leakage is not necessarily willful waste. It is mostly due to the lack of intelligent, concerted, concentrated and united action on the part of individuals who make up any given working force.

4. Every right minded man strives to prevent waste. So far as it concerns this company's work, it must be stopped. It is the purpose of these rules to prevent it, and to indicate the lines along which every member of our working force must work, to the end that the whole force shall act together as a unit, with one common object in view.

5. Team work is as imperative in our working force as in football. Perfect will be possible only when each individual not only does his own work, but backs up the work of his fellows as well.

6. Now, the object of this company is to earn dividends for the people who have invested their money in it; to earn dividends not only today, but tomorrow, next week, next month, next year, and all the following years, as long as the company shall be in existence. To do this, every economy must be practiced, every waste must be stopped, and above all and every other consideration, the service we sell to our consumers must be the best that their money can buy anywhere on

earth. It must not only be this, but each and every consumer must be made to feel that he is considered as one of the owners of the business. That, as it is his money which pays the company's dividends and the wages or salary of every employe, so is his business entitled to every attention, consistent with justice to all the consumers as a body, from every person connected with the company in any capacity.

OUR CONSUMERS THE MOST IMPORTANT PART OF OUR BUSINESS.

7. A little thought will make clear to any man capable of thinking why so much emphasis is nowadays placed on the necessity for courteous treatment to consumers. To say the least about it, you would think advice to be courteous to our managers superfluous. Yet, are not consumers of more importance than the manager, since, if we could not secure the consumers, we would have no use for him?

8. Courtesy is just consideration; putting yourself in the other fellow's place and seeing things, or trying to see them, through his eyes. When you have money in your pocket and go to buy goods, you expect, and rightfully, too, the merchant to show his wares to you, answer your questions and make an effort to please you. A little of this same spirit on the part of every member of our working force will make every consumer on our books a friend for life; establish our company the popular institution in this community and exterminate the kicker.

9. The early gas men maintained that a gas company's money was either made or lost in the retort house. Modern business methods, aiming more and more to give the man who pays the money what he desires, when and where and how he wants it, have so changed conditions that now, a gas company's fortunes are made by its distribution department.

10. Every man's home is his castle. If distribution men will only bear this in mind, the chances for friction with our consumers will be reduced to almost nil. When, in your work, you find a consumer's house closed, do not attempt to enter it unless your instructions on your orders provide for getting the key, or applying to some person for admission.

11. If you are to secure a key, learn, when getting it, if the house is furnished.

12. If unfurnished, secure the key, complete your work and return the key to where you got it.

13. If the house be furnished, ask for some one to accompany you to remain at the house until your work is completed. Should your request be refused, telephone the office for instructions and do not proceed with the work until you get them.

14. Whenever, in the course of your work, a consumer's gas is cut off by reason of it, you must exert every effort to get it turned on again with the least delay. Work overtime, if necessary, to do this. Remember that our business is to sell gas, and the best way to sell it is to always and at all times have it ready for every consumer who wants to use it.

15. Always go to the rear door of any house your work requires you to enter. If the work makes it necessary to use the front entrance, secure the consumer's permission first.

16. Always ring or knock and wait for the consumer or occupant to admit you.

17. Always clean your feet before entering. If cleanliness is more godly at one time than another, it is when you are working upon a consumer's premises. A little care will save a yard of complaint.

18. Never force or push your way into a house against the will of the occupant.

19. Always upon entering a consumer's premises, clearly state your business. Let your manner tell him as plainly as possible that as it is his work you are going to do, you want to consider his wishes in performing it.

20. Avoid at any cost any trace of officious importance in your dealings with consumers.

21. If your work requires you to ask an accommodation from a consumer, as, for instance, to use his telephone, don't forget to thank him, no matter how insignificant the favor may seem to you. Expressed appreciation will mollify the most crabbed human nature.

22. It must be clearly understood that every employe will be expected to see that any promise made to a consumer is

fulfilled. It should be a matter of personal pride with employes that every agreement made, be kept to the letter, and to this end you must not make nor imply a promise to a consumer unless you are certain that the promise can be fulfilled.

23. Whenever a consumer desires you to postpone work your are instructed to perform, telephone the office for instructions. Needless to say that this rule does not apply to cut-off orders for non-payment.

24. Whenever your work requires a consumer's property, of any description, to be moved, you must see that it is replaced in the same condition as you found it.

25. Whenever you find a consumer's property in such bad order that your work is liable to further damage it, before proceeding, call the consumer's attention to the trouble, being careful to have a witness to your conversation. If the consumer is unwilling to have you proceed with the work at his risk, telephone the office for further instructions. In any event, it is imperative that you make a written report of the matter, stating the whole situation clearly, on the back of your order. Always give the name of your witness.

26. Never in your work open or shut any water valves. The only exception to this rule would be when connecting or disconnecting gas apparatus also connected with water pipes.

27. Should you, unfortunately, be the cause of any damage to any consumer's property, report such damage to the office by 'phone at once, and make a full written report on the back of your order afterwards. Accidents will happen. Damage caused by carelessness or neglect will be charged to the employe responsible, but promptly reporting such damage, and energetic action to get it repaired with the least inconvenience to the consumer, will count more than anything else in having the fault passed over.

28. Always clean up after completing your work for a consumer. No matter how untidy the consumer's premises may be, clean up any debris or litter resulting from your work. Neatness and well ordered habits are one of the surest indications of a man's competence in his work. They will go further in fixing a favorable opinion of us and our methods

in our consumers' minds than yards of verbal expression of good will.

29. It is imperative that you never, under any circumstances, use or appropriate in or for your work any property or tools not owned by the company. Human nature has many curious phases, and some of it seems to lie awake nights to find an opportunity to claim damages. Take no chances, and you'll have nothing to regret.

30. We want all our employes to be men, strong men. One of the best evidences of strength is the ability to withstand abuse without returning it. Unfortunately, some of our consumers lose their tempers easily and become abusive. The right kind will always be sorry for it afterward. The other kind need not concern you. Be strong enough not to bring yourself down to the level of an abusive consumer by returning in kind.

31. Never, under any circumstances, make any comments, favorable or otherwise, about a consumer's gas appliances or anything in his premises. Some people have a wonderful faculty of misunderstanding. When you are on a consumer's premises, play safe. Least said, soonest mended. Now, this does not mean that you are not to answer questions. Every consumer is entitled to the fullest information you can give him about the part of his business which you are handling. It is part of your work to answer questions. Don't, however, volunteer information. Speak when you are spoken to, and then be sure you are right before you go ahead.

32. Never eat your lunch or hang your clothes in conspicuous places. We are as proud of our working force as we can be, but some of our consumers have æsthetic tastes, and it is just as much our business not to offend them as it is to give them better service than they can buy anywhere else. You'll have to admit, anyway, that a man absorbing the contents of his lunch box, or his old coat hung on the front fence, never adds to the beauty of the landscape.

33. Politeness and courtesy always pay big dividends. Anyway, we hope that our consumers will always have pleasant thoughts when they see any of our boys. It's a

mighty poor advertisement for us if your appearance anywhere causes somebody to put on a frown and think "damn."

34. Nearly all the suspicion of gas company methods has its foundation on gas company employes' lack of consideration, and it is up to us to prove to the public that we take as much, if not more, pride in serving our consumers well and honestly as any other institution that ever existed.

35. When it happens, as it sometimes unfortunately does, that for the protection of the company's interest action must be taken to which the consumer objects, as when gas must be cut off for non-payment of bills, a little consideration on your part will prevent the consumer from taking offense. At such times let your manner clearly show that while you are in sympathy with the consumer's predicament, the importance of the interests you are serving demands the action you are performing. Let your manner be conspicuous for the absence of any personal feeling, so that the power which is behind you will be plainly evident, and your earnestness will convince the consumer that you have no choice but to carry out your orders.

36. Be especially careful to report on the back of your order any statement which the consumer may make to you.

OUR EMPLOYES NEXT IN IMPORTANCE TO OUR CONSUMERS.

37. The business of supplying gas is one of the most important in the world, and this importance is increasing daily. The comfort and convenience of the greater proportion of the inhabitants of every city are becoming more and more dependent upon the use of gas. Our business offers to men of ability and capacity for assuming responsibility as magnificent opportunity as any other. Any man in the gas business who fails to recognize this has plainly missed his calling, and he owes it to himself to change either his point of view or his occupation without delay.

38. The man with a "what-I-can't-do-to-day, I'll do-to-morrow" disposition has no place in any gas company's distribution department. The nature of his service, to give our consumers gas when, where and how they want it, demands men of "do-it-now" dispositions; men who will, in an

emergency, stick to a piece of work until it is finished, without any regard to the clock.

39. You are earnestly urged to consider carefully Bishop Spalding's definition of success:

"Success lies in never tiring of doing; in repeating and never ceasing to repeat; in toiling; in bearing and observing; in watching and experimenting; in falling back on oneself by reflection, turning the thought over and over, round and about the mind and vision, acting upon it again and again—this is the law of growth. The secret is to do, to do it now, not look away at all."

Applied to our work by every one of our boys, this will increase the efficiency of our working force until it is equal or superior to the best in the world, and will make every man in our employ the success he should be.

40. While these rules are intended to serve as pipes to convey without waste the energy paid for in wages and salaries to the point where it is to be used, the utter impossibility of laying down hard and fast rules for every part of our work is recognized. Plenty of opportunity will arise for even the humblest member of our working force to exercise his own judgment.

41. Familiarity with these rules and actions at all times, in accordance with the spirit of them will, however, be considered as the first essential for continuance in our employ.

42. It is assumed that all of our people are gentlemen, who know how to respect themselves, and appreciate and are willing to give to the company the loyalty and support which they owe it.

43. Every employe, from the president to the man in the ditch, has his proper share of responsibility, and it is our earnest desire to give every one of our boys the same considerate treatment we expect from them.

44. If you consider that you have a grievance, take up the matter with your superior officer, or the superintendent, and it will be as carefully considered as conditions will permit. Don't nurse it, at any rate. Have it out or get out.

45. Suggestions for the better conduct of our business, and criticisms made in the spirit of helping to improve our work,

will always be gladly accepted. They will be considered as giving evidence of an employe's fitness for greater responsibility.

46. The address of every employe must be filed in our office, together with information for reaching him quickly outside of working hours, should an emergency require. Every employe must report in writing to his foreman, or immediate superior, any change in his address. With a business like ours, an emergency requiring the presence of every employe, may arise at any time. It is only common business prudence to be prepared to act quickly in case occasion requires.

47. Punctuality is a most important requisite in our employes. There is no difficulty in enforcing punctuality in the hours of leaving off work. There should be none in the hours of commencing. The man who is careless about being on time is usually just as careless about other things. Punctuality at all times is insisted upon.

48. When circumstances require your absence from work, be sure to send notice to the office. To the man who has a proper regard for the value of his own services, this rule will not be necessary.

49. The use of tobacco or intoxicating liquors is forbidden during working hours. Smoking is dangerous in any part of our work. Chewing, with its accompanying expectoration, is repulsive to our consumers, and the slightest odor of liquor about a man is sufficient to condemn him in the eyes of many people. A proper understanding of all the requisites of the service which we are selling to our consumers will convince any man of the absolute necessity for this rule.

Our service includes careful and considerate attention from every person connected with the company to every want, that has a legitimate bearing on or connection with his supply of gas, of every consumer.

It surely includes handling his work with decent, clean-mouthed men, who will not excite his suspicion of their competency to successfully perform his work.

50. Make an effort to convey, by your manner, an impression of strength in dealing with consumers. Nothing will do this better than a low, even tone of voice. Most men, when

they are not sure of themselves, speak loudly or use cuss words. Keep a good grip on yourself and you will always have a strong hold on your work.

51. No employe, not properly authorized to do so, can accept money owing to the company. Should a consumer desire you to accept payment for any bill, explain to him that your instructions positively forbid you to do so.

52. Vacancies will always be filled solely with the idea of securing the best results. Only capacity and fitness for the work will be considered. Long service alone never entitles a man to promotion. Other things being equal, the oldest employes will always be given the preference, but no employe need expect advancement unless he has made an earnest, persistent effort to fit himself for the duties of the higher position.

53. No man can know too much about his work. Our officers are always ready to answer questions and to give you every possible help in increasing your knowledge of our business. The man without the ambition to advance, and the willingness to pay the price of such advancement, is as dead as though he were buried. We do not want any animated corpses in our employ.

The *Philistine* says: "Every employe pays for superintendence and inspection. Some pay more and some less. That is to say a dollar-a-day man would receive two dollars a day were it not for the fact that some one has to think for him, look after him, and supply the will that holds him to his task. Make no mistake about this; incompetency and disinclination require supervision, and they pay for it; no one else does. Do your work so well that it will require no supervision, and, by doing your own thinking, you will save the expense of hiring some one to think for you."

54. Employes are expected to keep themselves posted upon all of the company's advertisements. It surely does not look well to you if, when you ask a clerk in a store for information concerning one of the store's advertisements, he tells you he knows nothing about it. Apply this to our business. Copies of our advertisements will be kept posted on our bulletin boards, and the employe who fails to keep himself informed

of them, so he can answer questions of consumers or intending consumers, will be considered so lacking in interest in the company's welfare as not to be worth longer employment.

55. Always wear your badge during working hours. We want to get together such a fine lot of fellows that every person in town will, when they see one of you, know at once where you belong. If you have a sort of sneaky, hang-dog feeling about wearing your badge, you want to lose either the feeling or your job right off. We aren't ashamed of having you with us, and we aim to treat you and everybody else so well that it will be a credit to you to let people know you are connected with such a solid and square dealing institution as ours.

56. It is most important that the office be in constant touch with all superintendents, foremen, inspectors and complaint men. Use the telephone for this. Call up at least twice each day and always before moving from one locality to another.

57. Employes must be careful not to give out information which solely concerns the company. Do not discuss the company's affairs in public, or in any place where you are likely to be overheard. The very walls seem sometimes to have ears. While there is nothing pertaining to our work which we fear to have known, a little information is a dangerous thing for some people. A little wholesome silence will save much troublesome explanation.

58. Excepting only consumers asking questions concerning their immediate business which you are engaged upon, inquirers must always be referred to the office, the proper place for transacting the company's business. Nothing in the above will excuse any incivility to the general public. The most valuable asset this company can ever possess is the good will of the public. Therefore, every employe must strive at all times to have his manner give the impression of good will to all men, without giving the thoughtless or ill disposed an opportunity to trespass upon the privileges to which we are rightfully entitled.

59. While helpful criticism will always be welcomed, be sure it is helpful before you make it audible. Anybody can

tear down a house. It's a difficult matter to build one. Be certain, too, before you venture to criticise a method or an order that you fully understand its purpose and realize its bearing upon the whole work. No officer of this company is issuing orders or devising methods just for fun. Every order or method is designed for some particular end, and often, when this end is understood, no foundation for criticism can be found.

60. Employes who make assignments of their wages or salaries, or who subject the company to garnishment proceedings, cannot be members of our working force. Assignments or garnishments are usually sure indications of loose habits of living, which unfit a man to produce good work. The great importance of our work forbids our using any but men of the best habits. Every effort will be made to protect faithful employes who meet with misfortune, if they will acquaint us of their trouble in time to help them.

ORDERS.

61. The necessity for keeping for future reference a record of all work done, and the number of people in our employ, whose work is concerned by such records, makes it clear why every piece of work must be covered by a written order.

62. If an emergency requires you to do a piece of work upon a verbal order, or without any order at all, always see that a written order is made out to record what you have done.

63. The importance of these records to the successful conduct of our business makes it imperative that every bit of information called for by our orders be filled in on them by the man who performs the work they cover. When our order forms are designed, some especial object is to be accomplished by each item of data requested. You are not to think that because your reports are accepted with certain blanks not properly filled in, that you are excused from supplying the requested information. Many times the press of work prevents proper scrutiny of reports, and the omitted data is not noted until occasion arises to use it.

64. Always perform your work in strict accordance with

your orders, paying careful attention to any special notes written on them.

65. Never erase any information given on an order. It is highly important that all our records be complete, and no employe is entitled to assume that any data given on an order will not be required.

66. The right minded man will know without being told that the orders he fills out constitute the original records which are the basis of all our records and reports. He will, therefore, take as much pride in making the reports clear and complete, and in keeping them clean, as he does in properly performing his work.

67. It is most important that orders be properly filled out immediately after the work is completed. They must be filled out on the job, not from notes taken there and afterward copied. Orders must be promptly returned to office as soon as work is completed.

68. Never abbreviate the information which should be reported about a piece of work for lack of space upon your order. If necessary, complete your report upon another blank of the same size as the order itself and attach the blank to it.

MATERIAL.

69. The material handled by our distribution department represents the expenditure of an enormous sum of money each year. The most insignificant waste may reach an appalling sum before it is discovered. Every man on our pay-roll must constitute himself a committee of one to effect an economy in the use of material.

70. No material must be taken out from our storeroom unless it be required by the work you are performing.

71. Every bit of material used must be charged out on your orders, so that its cost will appear against the work on which it was used.

72. You must see that every bit of material remaining after the completion of your work is returned to our storeroom. If it is impossible for you to return it promptly, you must

protect it from being stolen or damaged, and send a written order to the office to have it returned.

73. You must always carefully preserve driver's duplicate receipts for any material purchased and delivered direct to you on your work, and after O. K.-ing them, return them to the office promptly. Always note date received on such receipts and sign your name to them.

74. Every employe must make a written report to the office of any company material which he learns is liable to be lost, damaged or stolen.

75. No employe is allowed to purchase any material on company account, except on a written order signed by the proper official. If an emergency requires you to purchase material, always see that your purchase is covered by a confirming order. No bills for material will be paid unless they bear the proper order number and have been O. K.'d by the purchase and the person receiving the material.

TOOLS.

76. The company will furnish all the tools required to carry on any piece of work, and it will be your first duty to make the proper requisition for such tools as you may need to perform your work properly.

77. To prevent loss, you must sign a receipt for the tools furnished to you. These tools will then stand charged to you, and in the event of your leaving our employ their cost, unless they be returned, will be deducted from the wages due you.

78. Tools worn out or damaged in service will be replaced, but tools lost will be charged to the employes responsible for them.

79. Do not work with worn out tools. It wastes expensive energy and makes good work difficult, if not impossible.

80. Keeps tools in charge clean.

81. Employes in charge of wagons, service carts, etc., must clean them as often as necessary to give them a well kept appearance.

82. Do not lend tools. Tools represent the company's money, and they should be treated with the same care that you give your own.

83. Foremen must see that all street tools are properly cleaned and stored in tool box each night.

84. Drivers must never leave their horses untied, even for a few minutes. The steadiest horse may sometimes be startled unexpectedly, with disastrous results, so take no chances.

85. Bear in mind the purpose of tools and the great importance of properly caring for them will be clear to you.

DANGER OF EXPLOSION.

86. A gas man must never forget the danger of an explosion.

87. No fire must be used on any repair work for thawing frozen ground, or for any other purpose.

88. Smoking is especially dangerous, and is forbidden on this account.

89. Never attempt to find a leak anywhere with a light or apply a flame to light the escaping gas.

90. Leak must be located either by the sense of smell or the use of soap suds.

91. Never use matches or take an unprotected flame into a building. The company provides safety lamps for work where other lights will be dangerous.

92. Gas escaping through the ground has been known to be deodorized. There is only one rule to be followed with regard to fire or lights where there is the least possibility of gas being present, and that is most imperatively, DON'T.

93. Whenever you suspect a gas leak, immediately extinguish all open flame lights or any fire there may be in the neighborhood.

94. Whenever the odor of gas inside a building is reported to you, endeavor first to ascertain if the gas is escaping from the apparatus inside the building, or if the gas is leaking into the building from the soil outside, or from adjoining premises. If the odor of gas is very noticeable, immediately open the windows to ventilate the premises. After making certain that no gas is being used in the premises, examine the test dial of the meter or meters to see if any gas is being passed. If no movement of the hand on a 2-ft. test dial can be detected

for ten minutes, with the gas pressure on the meter and no gas being used, it can be safely assumed that there is no leakage in the house piping and fixtures. If the hand on the test dial moves in this length of time, with no gas being used, endeavor to locate the leak. If you can find it, and it can be readily repaired, remedy the trouble. If it cannot be repaired at once, or if the leak is in apparatus which the consumer should stand the expense of repairing, soap up the leak temporarily and notify the consumer that you will have the trouble remedied, or tell him to get a plumber, as the case may be.

95. If gas is coming into the building from without, inspect the adjoining premises, if the house is one of a block, or notify the office at once if you suspect the leak to be in either the services or mains in the street.

96. Never, under any circumstances, leave a leak until you have remedied the trouble, unless you are absolutely certain that it is of the most trivial character, or have made absolutely certain the impossibility of an accident.

97. In the case of a broken main, accompanied by the escape of a large volume of gas, the convenience of some of the consumers must be sacrificed. Locate the break as closely as possible from observations at places where the escaping gas is noticed, and then bag off the section of the main in which the leak is located.

98. Leaks of this description are exceedingly dangerous, and work must not cease until they are located and remedied.

99. Do not hesitate to warn smoking bystanders or loiterers where repair work, in which gas is escaping or likely to escape, is being carried on.

ASPHYXIATION.

100. Whenever a man has been overcome with gas, it is the result of carelessness. A few simple precautions will prevent anybody from being gassed. As accidents will happen, however, these rules are given, so that in the event that such an emergency should arise, you may know just what to do.

101. Asphyxiation is the suspension of the vital functions from causes affecting the respiration or breathing.

102. As long as the victim has not lost consciousness there is little cause for alarm.

103. The first thing to do is, of course, to give the victim plenty of fresh air and then call a doctor. If he is able to move, keep him walking about, as the exercise helps the respiration.

104. Give the victim a glass of weiss beer, vichy water or any other carbonated water, or, if these are unobtainable, give him a pint of water in which a teaspoonful of baking soda has been dissolved. If he is very weak, give him thirty drops of aromatic spirits of ammonia, and repeat the dose every five to fifteen minutes, until four doses have been given. If more than four doses be given, the patient will be nauseated.

105. If the victim has lost consciousness, lay him on his back, with a tightly rolled coat under his shoulders, in order to throw his head well back. Open his clothes at the throat, chest and abdomen. Roll up the trousers from the legs. Supply heat to the extremities, either by vigorous friction or by hot bricks, hot water bottles, plates, etc. Pull the tongue out of the mouth and hold it firmly to prevent its slipping back and falling into the throat. Make the victim breathe by kneeling at his head, grasping his arms at the elbows and pressing them vigorously to his sides; then straighten the arms, pulling them back until the hands meet over the head; then return the arms to the sides, fold them across the chest, pressing them across the chest, pressing them down hard. Repeat about four or five times a minute, being careful not to make the motions too rapidly. The sole object of the motions is to fill the lungs with air and empty them in imitation of the natural breathing.

106. During the entire process of artificial respiration, have your assistants apply heat to the extremities, either by friction or by hot water bottles, bricks, plates, etc., and slap the chest with a wet towel.

107. The restoration of asphyxiated persons has been accomplished at long periods after apparent death, so be prepared to continue your artificial respiration until a doctor pronounces the victim dead.

108. The work, to be effective, is very tiresome, and ten

minutes at a stretch is about as long as one man can administer the treatment effectively. On this account change operators before their strength is spent.

109. When the victim begins to breathe naturally, give him a dose of aromatic spirits of ammonia, as before directed, and cover him up warmly until you can move him.

TO PREVENT ASPHYXIATION.

110. Never work on leaky gas mains, or do work on mains or services in which gas must be allowed to escape, until the trench has been made large enough to thoroughly ventilate it and afford ample working room.

111. Never do such work in tunnels or under the overhanging banks of trenches, unless you are especially instructed to do so by the superintendent and you are working under his guidance.

112. When performing such work, always station a man on the bank to keep the workers in sight and get them out of the ditch promptly, if necessary.

113. Every gang on such work must be provided with life belts and a rope long enough and strong enough to pull the men out of the trench.

114. Never enter a house or building filled with gas without first providing the means of getting out quickly in case you are overcome. You can do this by attaching a rope to yourself when you enter and leaving the other ends in charge of assistants, who can then get you out, if necessary.

115. These precautions may seem unnecessary to you, but you must remember them, and use them should an emergency arise. Human life is precious, and must not be exposed to danger heedlessly.

COMPLAINTS.

116. If there is any one division of gas distribution work that is more important than others, it is that which cares for consumers' complaints.

117. A good complaint man is a treasure worth his weight in gold to any company. Our complaint men either make friends or enemies for us. There is no middle course.

118. Do not consider from this that there is anything difficult or complicated about complaint work. It is just as simple as getting gas through a straight line of pipe, if you have an ample supply at the end from which you want to take the gas.

119. Just picture to yourself, when you are called upon to remedy a complaint of no gas, or poor gas, the consumer's apparatus, from the main to the last burner, as a straight line of pipe, each burner or appliance representing a tee in the pipe, and the meter outlet, meter inlet and service pipes, other tees.

120. With this idea in mind, you will have no difficulty in locating the consumer's trouble. All it requires is a little patient observation. The first thing to do in caring for a complaint of poor gas is to question the consumer, or the occupants of the premises for which the complaint has been made, as to the precise nature of the trouble complained of.

121. Evidently, if the consumer is having trouble at all of his burners and appliances, represented by the tees in the imagined straight line of pipe, the trouble can be found in the line between the tees representing the meter outlet, and the meter inlet, service pipe or main, unless trouble is in the main itself.

If you cannot gain intelligent information by asking questions, then light up the consumer's burners or appliances and make your own observations. Always endeavor to light the same burners or appliances as are in use when the consumer most notices his trouble.

122. If there is a uniform lack of pressure throughout the burners and appliances, with an apparent increasing drop in the pressure as each succeeding burner or appliance is turned on, then a stoppage of solid matter at some point in the piping, or piping that is too small, would be indicated.

123. In this connection, a pocket syphon gauge to indicate the pressure at the several points in the piping, will be of great assistance, although with a little practice the drop in pressure will be plain to the eye from observations of the flames in the various burners and appliances.

124. A quick sharp jumping of the flames would indicate a

stoppage caused by a collection of liquid at some point in the piping.

125. A slow, regular rising and falling of the flames at frequent intervals would indicate a meter overloaded or sticking at some point.

126. If the trouble is found only at one point, evidently it is in the branch pipe supplying the apparatus where the trouble is found, or in the apparatus itself. In this case the trouble is easily located by patiently examining the appliance and piping step by step until the stoppage is found.

127. If the trouble is common to all the burners and appliances, then first remove the plug from the tee in service where it enters the building.

128. If the trouble is caused by water or liquid in the service pipe, it will be made plain to you by the gurgling sound or intermittent flow of gas when you remove the plug. Never, under any conditions, allow any condensation from a service to escape into a consumer's premises. To permit this is to create as great a nuisance as though you had given a polecat the run of his house.

129. If the trouble is caused by a stoppage in the service, the lack of velocity or force of the flow of gas, or the small volume of the flow, will tell the story to you when you remove the plug, or, you can detect it by applying your mouth to the tee and blowing into the service pipe.

130. If the stoppage is in the service pipe, clear it by pouring gasoline or naphtha into the pipe and then blowing into it with your lungs, or better still, with the service pump. In forcing a service with your pump, always make sure that all meters connected to the service are shut off. After forcing a service with a pump, always light up the consumer's burners or appliances to remove the air blown in the service pipe.

131. If this fails to remove the trouble, then rod the service pipe with a wire.

132. This failing, make an examination of the service pipes in neighboring houses to make certain that the trouble does not exist in the main. If you find these services in good condition, then order the service pipe dug up.

133. Always make a complete separate written report on

any service in which you discover water or condensation, for the guidance of the service men.

134. If you find the service pipe clear, then examine the meter inlet and the meter outlet, paying special attention to the connections, to ascertain that they are not flattened, so that they obstruct the flow of gas.

135. Be patient and persistent and you can locate the most obstinate case of trouble.

136. Never assume that a consumer's complaint is imaginary. Consumers do not make complaints just for fun. There is some foundation for their reports of trouble and it is up to you to find it and prevent the recurrence of the complaint. If you can't locate the trouble, don't be afraid to tell the consumer so, but be sure to tell him, too, that you will get assistance and keep after the matter until his trouble is remedied.

137. It is a lot better for us if you can only remedy one complaint a week, if you stop the trouble so that it will not occur again, than if you make a hundred calls a day which you will have to repeat again in a little while. Frequent repetitions of the same trouble will sour the best natured man in existence. Our consumers are paying us for good service, and we are paying our complaint men to give careful attention to our consumers' troubles and to remedy them to stay remedied, when it is our work to do so.

138. If you cannot locate the source of a consumer's trouble, after a careful and painstaking investigation of every bit of his apparatus, put on a recording pressure gauge for a few days to get a record of actual pressure conditions in his apparatus.

139. Do not take down a consumer's chandeliers or gas brackets unless especially instructed to do so.

140. If you locate a stoppage in the consumer's piping, be especially careful in endeavoring to force it out, that you do not make matters worse.

141. When you find a stoppage in a consumer's piping that you cannot force, inform the consumer of the location of the stoppage and request him to have the piping opened up to be cleared. In such cases, make a special written report to the

superintendent, stating exactly what the trouble is, what you have done to remedy it, and what you have advised the consumer to do.

142. In forcing a consumer's piping, first disconnect the meter outlet and bend the connection to catch in a suitable receptacle any matter which may be blown out of the piping. Attach your pump to the first opening from the meter and give the piping a shot, then proceed to the next opening and so on until you have cleared the whole piping.

143. In a case of a stoppage in a consumer's piping, difficult to dislodge, the trouble may sometimes be remedied by filling the piping near the point of stoppage with gasoline, allowing the gasoline to stand several hours, and then forcing the gasoline out with the service pump.

144. Do not hammer old piping to loosen scale, rust, etc. It is dangerous, for you can never determine what defects such hammering will develop.

145. Pay especial attention to the consumer's burners when attending complaints. Always put on new tips wherever necessary and explain to the consumer that tips, like everything else, need attention at times. If the consumer is using open flames with glassware, always put on Bray burners, so that no complaint of cracked globes will come in. The complaint man who permits ragged open flames to pass in his work is guilty of gross carelessness or ignorance.

NAPHTHALINE COMPLAINTS.

146. Frequent complaints from naphthaline inside the premises, from any consumer, are almost invariably the result of some bad condition in his service pipe, extension, meter, or meter connections. The cause will almost always be found at some point where the flow of gas is restricted. It may be in too small a service extension, too small a meter, too small connections, flattened connections, service pipe or meter exposed to chilling drafts, of great variations in temperature, or something similar. The cause will be made plain by a little patient study. Successive complaints from naphthaline stoppage inside a consumer's premises stamp a complaint man as careless in his work.

FROST COMPLAINTS.

147. Make a complete written report upon all services or consumers' piping found stopped by frost.

148. A shot of wood alcohol will in nearly every case free a frosted service, but frosted services are, as a usual thing, the result of bad work, and it is up to us to prevent their occurrence in another winter, unless conditions in the consumer's premises are so bad that the trouble cannot be remedied.

149. When frost trouble is found in the consumer's piping, make a complete report with diagram, if necessary, of what changes are necessary to stop the trouble, so that the consumer can be advised by mail that it is up to him to provide the remedy, and at the same time he can be informed just what he should do.

HIGH BILLS.

150. It is not the work of the complaint man to explain high bills to consumers, whose complaints he attends, how to read their meters and how to prove their gas piping is tight, by observing the hand on the test dial of their meters when no gas is being used.

151. Endeavor to induce the complaining consumer to keep a record of the gas he uses each day.

152. Emphasize the fact that consumers who read their meters regularly, at frequent intervals, and know from actual measurement just what gas they use, never have to complain of high bills. It's only the waste that makes excessive gas bills, and if grocers, butchers and such people, sold their product by the month, with payment after the stuff had been consumed, their complaints would be far more numerous than any gas company's.

153. When a consumer calls your attention to a complaint of a high bill, always make a note of it on your order, together with the number of the consumer's meter and the statement at the time the complaint was made. This will show consumers that their complaints are at least not falling on deaf ears, and your statement will be of great assistance to the office in checking up the consumer's complaint.

LEAK COMPLAINTS.

154. In investigating complaints of leaks you must report:
The location of the leak.

State definitely whether it was on the outlet or inlet of the consumer's meter.

If in the meter itself, did the meter register the leakage.

And finally, how much gas was leaking, as determined by timing the movement of the hand on the test dial of the meter at least ten minutes, together with the statement and number of the meter.

155. A leak complaint is almost invariably followed by a complaint for an allowance for gas lost. This is especially so if the leak is found in work installed by the company, such as a stove line, or the meter connections.

156. All of the information asked for is required, either to satisfy the customer that he is not being overcharged, or to make him a just allowance, if he is entitled to any.

157. Do not use matches or candles to hunt for leaks. Brush the joints and piping with soap suds, smell along the piping, or pass the fingers over it, listening for the hiss of escaping gas, if the leak is a large one. One part gas in sixty thousand parts air can be detected by the sense of smell. One part gas in seven parts air forms an explosive mixture.

158. Any leakage which causes the movement of the hand on the dial in less than ten minutes should be considered serious, and the gas should be cut off.

159. A consumer's piping and fixtures may be quickly tested for leakage by removing the meter and setting in its place a test bottle. The test bottle is so arranged that any gas passing through it must bubble through the water contained in the bottle. The rate of leakage is indicated by the rapidity with which the bubbles of gas rise through the water, and the piping is proved gas tight if no bubbles appear.

160. The consumer can usually assist in locating the leak if you will question him.

161. Examine carefully all exposed gas piping and all fixtures and appliances. If you cannot locate the leakage this way, trace out the probable location of the gas piping from

the location of the fixtures, and carefully smell along any cracks in the flooring or along the baseboards, or at sliding door openings near the piping.

162. If you locate the leak and it is the consumer's apparatus, advise him and request that he get a plumber to repair it.

163. If an inspection fails to locate the leakage in a consumer's apparatus, advise him and request him to get a plumber to locate and repair it.

164. If you find the leakage and are unable to make permanent repairs, either because it is in the consumer's apparatus and should be remedied by him, or because you must secure proper material, soap up the leak and advise the consumer, either that he must effect the proper repairs, or that you will return to do so.

165. If you find gas coming into the house from the street, open the basement windows for ventilation and immediately telephone the office for instructions. If you find the gas entering the consumer's premises from the adjoining premises, carefully examine the piping there. When you have located the leak, repair it, if you should do so, in accordance with the foregoing instructions, or cut off the gas and notify the consumer responsible for the premises, to effect the required repairs.

166. If you find gas coming from a vacant or closed house and cannot locate the custodian, call a policeman and have him force an entrance, or 'phone the office for instructions.

REGULATING GAS STOVES.

167. The proper way to adjust or regulate a Bunsen, or atmospheric burner, is to open wide the air mixer and then cut down the gas supply with the gas regulator, if there is one, or by closing up the orifice that admits the gas to the mixer, if there is no gas regulator, until just enough gas is flowing into the burner to prevent it lighting back.

168. The proper flame in a Bunsen or atmospheric burner is one in which each separate jet at each hole seems burning alone by itself, not impinging or touching at any point the jets adjacent to it, and burning with a greenish cone in the

centre of the jet; the cone having the appearance of a vigorous swirling motion, as though the envelope of flame was endeavoring to force the green cone down through the hole from which it issues.

169. Should a consumer insist upon having a large mass of blue flame above his burners, demonstrate to him the better efficiency of the flame just described, by heating to the boiling point a small pan of water over the flame he wants, carefully noting the time required, and then repeating the operation with the same quantity of water over the burner adjusted as you are above instructed, again noticing the time.

170. Always explain to a consumer the necessity for keeping all burners and appliances scrupulously clean.

171. If burners are badly incrusted with grease, they can be cleaned by boiling in strong lye water, or in very bad cases, by heating to the point of redness over a fire. In heating burners to clean them, extreme care must be used to prevent them overheating, or they will be ruined.

172. The tops of stoves can best be cleaned with gasoline applied with a stiff scrubbing brush. In using gasoline, remember that because of its extremely volatile nature it is far more dangerous to handle than gas. Never use gasoline in a room where there is a fire or an open flame of any kind. Never light a burner in, or take an open flame into a room where gasoline has been used until the room has first been thoroughly ventilated.

173. An excellent stove cleaner and polish is made as follows: Dissolve 2 ounces of beeswax in 1 quart of gasoline and then add one-quarter of a pint of turpentine. Shake well before using. Give this formula to every consumer whose gas stove you inspect.

174. In cleaning and adjusting gas stoves, never neglect to remove the dust and lint which collects in the air mixers.

175. Complaints of ovens burning on the bottom may be caused either by heating the oven too hot or by poor pressure in the oven burners. In the latter case, the trouble would usually be indicated by the usual length of time necessary to heat up the oven.

176. Complaints of not baking on the bottom are usually caused by failure to evenly heat the oven before commencing baking operations and then placing the baking too high up in the oven.

177. Complaints of bad odor from gas stove burners are nearly always the result of too much gas in the burners. Cases have been known where inexperienced cooks lighted the burners in the mixers.

WATER HEATERS.

178. The instructions concerning the regulation of gas stove burners also apply to water heater burners.

179. In complaints of failure to heat, first examine the burner to ascertain that it is burning properly.

180. If the heater has been in service for a considerable length of time and the water used is unpregnated with lime or other similar substance, a collection of sediment in the heater coils may be the cause of the trouble.

181. Too many elbows in the water connections or too long connections between the water heater and reservoir always make the circulation sluggish and good results in a water heater are dependent upon quick circulation, so that the greatest difference in temperature between the products of combustion from the gas burned and the water to be heated may be maintained.

182. Unless there is a constant upward rise of the hot water connection from the water heater to the reservoir, with the hot water supply pipe to the house taken off from the highest point in the hot water connection, sluggish circulation will surely result from the air pockets formed by any different run of the hot water connection.

183. Complaints of bad odor from a water heater will always result unless the heater is connected to a flue with sufficient draft to carry off the products of combustion. Too much draft will mean wasted gas, because of the excess amount of cold air drawn through the heater.

184. Complaint of improper working of an instantaneous water heater should always first be investigated by attaching a syphon gauge to the supply pipe and noting the pressure when

the heater is lighted. Some instantaneous heaters on the market require 120 feet of gas per hour at a pressure of 15 tenths to operate them.

185. Automatic instantaneous water heaters, heaters which are automatically started by the turning on of hot water faucet anywhere in the house, require 200 feet of gas per hour, and over, for their successful operation.

186. Complaint of water from an instantaneous water heater showing soot usually requires the cleaning of the dust from the screens protecting the air openings in the burners. This complaint arises from heaters in which the products of combustion come directly in contact with the water heated.

187. Whenever screens are placed over air openings of water heater burners of any type, they require periodic cleaning. If this attention is not given them, the burners will not receive sufficient air with the gas to be burned, and inefficient operation, with the production of soot, will result.

188. The flue pipes of instantaneous heaters also require close inspection. They must be unobstructed and have sufficient draft to carry off all the products of combustion, without any probability of any down draft. As the products of combustion leave the heater at a high temperature, the outlet of the flame must not be near any inflammable material.

INCANDESCENT BURNERS.

189. The proper manner to adjust an incandescent burner is, after burning off the mantle, to open the air shutter wide, then light the burner, giving it more gas than is required, as shown by the flame above the mantle. Then slowly cut down the amount of gas with the regulating device until the greatest amount of light is being obtained from the mantle.

190. Mantles deteriorate with use, and the cause of poor light is often the use of mantles whose useful life has expired.

191. When putting on a new mantle, always examine the gauze cap. Dust frequently collects under the gauze and obstructs the free passage of the gas and air mixture. Clean the burner thoroughly before putting on the mantle.

192. Too little gas in an incandescent burner will make the

light flicker, and too much will cause a deposit of carbon on the mantle, blackening it.

193. Inquire of a consumer complaining of incandescent gas burners the length of time they have been used. After carefully examining the lamps, and finding no trouble, suggest the purchase of new mantles if the old ones have been in use over six months.

194. It is highly important that the glassware on incandescent gas lamps be kept clean, in order to secure the best light from them. Call the consumer's attention to this if conditions make it necessary.

195. The above instructions apply to arc lamps as well as single burners. For satisfactory lighting service, good pressure, good mantles, clean burners and gauzes, and clean glassware are absolutely necessary.

196. Careful attention to these points will remedy any reported trouble from incandescent burners or arc lamps.

197. To clean shades, ceiling plates and globes of gas arcs, apply whiting with a damp cloth and then rub to a polish.

OTHER CORPORATIONS' PROPERTY.

198. You must bear in mind constantly that other corporations possess the same rights and privileges in the streets that we do.

199. It is our policy to preserve the most friendly relations possible with everybody in this community. As a rule, whatever will injure another corporation's property will also injure our own. While it is not intended that you shall perform any of the work which should be taken care of by their own employes, we shall expect you to have a friendly interest in anything likely to result in damage to their property, which may come to your notice. In such an event, make a prompt report to our office. We should appreciate a similar courtesy from other corporations' employes, and we certainly should give others the same treatment we ourselves expect.

200. Whenever, in the course of any construction or repair work, any other structures in the street are endangered, every precaution must be adopted to protect them.

201. Unless it is made imperative by an emergency, never open or enter any sewer, water main, or conduit manhole, except when an employe of the owner of such manhole is present.

202. Whenever in the course of any work, any other corporation's property, such as sewers, water pipes or conduits, or the like, are opened up or exposed, keep a careful written record of their exact location and condition, together with a description of what you have done in disturbing or protecting them.

203. Forward your record promptly to the superintendent. It may be of the greatest importance in case of any claim being made for damages.

204. Never disturb or perform any work of any character on any other corporation's property, unless it is to protect such property from damage resulting from any work which we are carrying on.

205. Never disturb in any manner any land marks or stakes set for any purpose.

206. Always make to the superintendent a complete written report of any damage done to any structure or property of another corporation, stating clearly the cause of the damage and what steps, if any, were taken to prevent or remedy it.

207. Whenever any of our work necessitates the changing of any water pipe, sewer, conduit, or any similar structure, note and make a written report of the labor and material required for such changes. Your report is necessary for the checking of charges made for such changes.

208. Never move or tamper with any letter box. The Post Office authorities must be notified in case any of our work requires the removal or changing of any letter box, even though such change is only temporary. Disregard of this rule will lead to serious trouble.

209. Always, in any street work, keep a clear space around letter boxes, fire plugs or hydrants, fire alarm stations, patrol boxes, etc., and keep open a free passage to them.

ACCIDENTS.

210. Webster says "an accident is an event which takes place without one's foresight or expectation; an event which

proceeds from an unknown cause, or is an unusual effect of a known cause, and therefore not expected."

211. Most accidents are the result of a lack of foresight. Therefore it is up to you, when performing a piece of work, to be habitual in considering what may happen as the result of the various things you do or leave undone in completing it.

212. Should it be your misfortune to meet with an accident, first see that prompt and proper attention is given to anyone injured. Call a doctor immediately if the injury seems serious. See that the victim is properly cared for, and his relatives, or people closely connected with him, are notified. Next, protect immediately from further injury any property that has been damaged.

213. Telephone to the superintendent or office immediately, advising clearly just what has occurred, and then follow carefully any instructions which may be given to you.

214. Make a complete detailed written report of everything connected with the accident, not forgetting to note the date and the precise time at which the accident occurred.

215. If anyone is injured, report name and address of victim, injury, where sent and how, and name of doctor called.

216. Secure the full names and addresses of any witnesses of the accident. Report any comments such witnesses may make concerning the accident. State, as nearly as you can determine it, the cause of the accident and illustrate your explanation with a diagram, if possible.

217. You must make such a written report of every accident which may occur in your work, no matter how trivial or insignificant it may be.

218. Do not neglect a similar report of any personal injury to yourself, no matter how small it may appear to you.

MAIN WORK.

219. "A perfect piece of work is that in which the interest on the final cost, plus the annual depreciation, plus the cost of operation, is the least sum possible of attainment."—Gillette.

"Trifles constitute perfection, but perfection is not a trifle." —Michael Angelo.

220. Gas main layers cannot do better than to bear these

definitions of perfect work constantly in mind, since so many men consider that low first cost only is the object most to be sought. They also fail to recognize that careful, painstaking attention to the little details of their work is the only true way of producing perfect results. Because their work is buried from sight, they frequently let go as good enough, work which they would never dream of passing were it in plain sight and subject to frequent inspection.

221. Good enough in gas main and service work is the cause of more wasted dollars in gas lost, disgruntled consumers, accidents and damage to the company's good name, than from all other causes added together.

222. If there is any one department of our work, in which, more than any other, only the best obtainable should be accepted, it is in laying mains and service.

223. The foundation on which gas mains rest is the most important part of gas main work. A solid foundation means gas mains permanently tight, and it matters little what style of joint be used, if each section of pipe be bedded solidly, beyond the possibility of settlement, for its entire length.

224. This means that when the trench is dug to nearly its proper depth, the level and straight edge must be used to carefully grade the bottom of the trench, so that no blocking of any character whatever will be required to give the pipe its proper grade.

225. IT IS IMPERATIVELY NECESSARY THAT EACH SECTION OF GAS MAIN PIPE BE BEDDED SOLIDLY FOR ITS ENTIRE LENGTH, ON THE SOLID UNDISTURBED EARTH, AND DEEP ENOUGH TO BE UNDISTURBED BY FROST. GOOD MAIN WORK IS IMPOSSIBLE WITHOUT THIS.

226. Gas main must always be located on the same side of the streets running in the same direction and at the same distance from either the centre line of the street, or the curb, or property lines, unless structures previously erected in the street prevent this arrangement.

227. You must always be sure that a permit has been secured from the city authorities, before making any opening in a street.

228. Gas mains must be laid in straight lines, parallel with the centre of the street.

229. If conditions make it necessary to vary the location of a gas main from its location, relative to the centre line of the street, at which the main was started, or, in other words, to offset the main, that portion of the main which is not parallel to the centre line of the street, must be made as short as possible without introducing sharp angles in the main.

230. As open trenches are a most prolific source of damage claims, main work must be planned that as much as possible of a trench shall be filled on the same day it is opened.

231. Any trench remaining open at night must be properly barricaded and protected with lanterns spaced not more than 20 feet apart. It is the duty of every main or service foreman to see that this precaution is taken on every piece of work in his charge.

232. On starting a piece of main work, first line out the trench. In clay or other hard soils the trench for pipe from 4 in. to 10 in., need only be wide enough for a man to work in with a pick and shovel.

233. In sandy soils, or soils likely to slide, the trench must be started wider, to give a batter or slope to the side sufficient to hold them in place. If necessary the sides of the trench must be shored or sheeted to prevent them from caving.

234. Before throwing out any earth, roll the pipes into place along the location of the trench, with the bells pointing in the direction the pipe is to lay.

235. If possible, throw the earth on the side toward the centre of the street to form a barricade.

236. On macadamized or graveled streets, or where the top soil is of a different character from that below, keep the macadam, gravel or top soil separate from the rest of the earth taken out by throwing it on one side of the trench (gutter side) and casting the earth excavated from the trench below the top on the other side (centre of street side.)

237. While we aim to have all of our street main work so carefully done that every citizen of the community will at once recognize our work from the thorough placed manner in which it is conducted, there are many people who are unobserving. You must, therefore, see that plenty of our advertising signs are prominently displayed on every piece of street work under

your charge. We are proud of the spirit of progress our street work indicates, and we want every citizen of the community we serve to know it.

238. On paved streets, pile the paving material in neat piles along the curb.

239. The gutters must be kept unobstructed to prevent damage in case of a storm during the progress of the work.

240. Cross streets, or much used passages, must always be kept open, temporary plank bridges being erected, if necessary.

241. A clear space around, and an unobstructed passage to, must be maintained at each fire plug, mail box, fire alarm station, etc.

242. Before any pipe is laid at an intersecting street, the trench must be opened full depth entirely across the intersection, to ascertain that no obstruction will be met in laying the pipe at the intended grade.

243. The bottom of the trench must be given all the grade conditions will permit, at the same time keeping the low points which make drips necessary, as few as possible.

244. When the grade and the flow of gas in the mains will be in the same direction, the bottom of the trench may, if necessary be run almost level for considerable distances.

245. When the grade and the flow of gas will be in opposite directions, a grade of one-quarter of an inch in 12 feet is the least allowable.

246. After the bottom of the trench is graded, measure off the location of the bells, if cast iron pipe is to be laid, and excavate the additional depth required, before any pipe is laid.

247. In refilling trenches, the earth must be first solidly rammed into place under and at the sides of the pipe, in the same manner that railroad ties are tamped.

248. Then, if the character of the soil permits, the remainder of the earth filling may be flushed with water, to solidly refill it. If the nature of the soil, such as clay forbids flushing, then the earth must be rammed into place in thin layers, working at least two rammers for one shoveler.

249. All of the earth thrown out must be put back in the trench, so that the street will be left in as good condition as

before the main work was started, with no possibility of further settlement.

250. Pipes must not be laid in soil composed of ashes or cinders, and ashes or cinder must not be filled in around pipes. If you find such soil in your main work, immediately report the conditions to the superintendent and ask for instructions. Should an emergency require you to act without such instructions, cover the bottom of the trench with at least 1 inch of cement mortar, composed of three parts sand to one of cement, lay the pipe upon this and then cover the pipe with at least 1 inch of cement, making sure that no portion of it is exposed to the ashes or cinders.

251. It is the policy of the company that its street work be a standing monument to the community of our sense of responsibility for the work we carry on.

The first cost of thorough work is greater than the expense of careless, slovenly work, but, leaving out of consideration the pride every man should have in doing his work to the best of his ability, if it earns for us the public confidence that whatever we undertake will be well done, the increased cost of doing our work thoroughly will pay us larger dividends than could be secured by any other investment.

252. Keep and forward to the superintendent promptly upon the completion of the work a record of the exact location of all services, water pipes, conduits, or any underground structure uncovered during the progress of the work. Make your measurements, giving the locations, clear by means of diagrams.

253. If any such underground structure is disturbed in any manner by our work, include in your report an explanation of what was done to it, so that in case damage claims are presented, they may be properly handled.

254. Make an immediate written report to the superintendent of any work, such as replacing pavement, curbing, cross walks, gutters, etc., which you are unable to complete, so that the necessary steps may be promptly taken to prevent any complaints from the city authorities, or from the residents along the street.

LAYING THE PIPES.

255. As the pipes are distributed along the side of the trench about to be dug, test each piece carefully with a hammer for imperfections. When making such a test, the pipe should be supported near the centre, with the ends free from contact with anything. A clear bell-like sound, resulting from a blow of the hammer, indicates sound pipe.

256. Lower the pipes into the trench by means of ropes long enough so the men handling the work will not cave in the sides.

257. Just before each pipe is placed in the trench, carefully swab it out to clear it of all dust, dirt or debris that may be contained in it.

258. As each pipe is being lowered, the main layer in the trench must look through it, to ascertain positively that no dirt or obstruction remains in it. Too much attention cannot be given to this one point.

259. The pipe being lowered into the trench, the main layer places a twisted strand of yarn, large enough to fit tightly in the lead space of the hub, on the spigot end, enters the spigot into the bell, and, assisted by the men on the ropes, forces the spigot into the bell. The ropes are then removed, the ends of the yarn crossed over the top of the pipe, to keep the dirt out of the joint until it is made up, the pipe forced home with a bar used as a lever across the bell end of the pipe just laid, a temporary wood plug is placed in the open end of the pipe in the trench, and then the pipe is lined up with the main already laid and held into place by tamping earth around it.

260. Then excavate the additional width of trench required at the bell for making the joint, throwing the earth around the point and ramming it into place.

261. In sandy soils, likely to slip or cave, the space not required at the bell for making the joints can be filled as soon as the pipe is in place.

LEAD JOINTS.

262. The calker (in extensive work, one or more yarners

are used for this work) then drives up the yarn placed in the joint by the main layer, and puts in additional yarn until an even space 2 inches in depth remains for the lead.

263. The yarn used must be twisted into rolls large enough to require driving into the joint.

264. Driving up the yarn must be evenly done, so the spigot will remain exactly centered in the bell.

265. The ends of the strands must be carefully lapped, so that the depth of yarn will be uniform around the entire circumference of the joint.

266. As much care must be used in driving up the yarn as in calking the lead. The yarn must be compacted in the joint as tightly as is possible without forcing any of it past the spigot end. A joint properly yarned will be gas tight with only the yarn in the joint.

267. The yarn being driven up, put on the joint runner, which can be either a rubber or asbestos band, held in place with a clamp, or a ring of fire or common clay with a yarn core, to make it easy to apply or remove.

268 Whichever sort is used, the shape must be such as to leave a continuous ring of lead extending beyond the face of the bell, so that the finished joint will be flush with the face of the bell.

269. Use only new pig lead for joints.

270. Have the lead hot enough to quickly char a dry pine stick dipped into it.

271. Skim back the dross before filling the pouring pot and run the joint with but one pouring.

272. The lead must form an unbroken collar inside the bell.

273. If a joint is not properly run, the lead must be cut out and the joint run over again.

274. It is false economy to attempt to economize on the amount of lead required for making a joint.

275. In a gas main laid on the solid, undisturbed earth below the frost line, lead joints first properly filled with lead and then carefully calked will remain permanently tight.

276. Drive up the lead gradually and evenly, entirely around the pipe, starting next the spigot with the small calking iron and using the larger irons as the lead is driven up.

278. The lead is properly calked when the average blow of the hammer, the calking tools leaves no mark on the lead, and the large calking tool has detached the surplus lead without the use of a cold chisel, by simply compressing the lead against the inside of the bell until the surplus is sheared off.

279. When finished, a lead joint should show an even surface without tool marks, and the lead so closely driven up to the iron as to appear welded to it.

CEMENT JOINTS.

280. In making cement joints, the first requisite is an absolutely rigid pipe. Any movement or disturbance of the pipe before a cement joint is properly set, will ruin the joint.

281. Before any work, therefore, is done on cement joints, enough earth must be rammed around the pipe to hold them rigidly in place.

282. The second essential is that the yarn be driven up gas tight, and that the cement set, not dry out. The yarn used must either be tarred or water soaked and the completed joint be protected to prevent the evaporation of the water in the cement until the cement has set.

283. The cement must be mixed fresh for each joint with one volume of water to three to four volumes of cement. The temperature when the work is done will govern the amount of water required, the higher the temperature the more water being necessary. The cement must be mixed as stiff as is possible to work it. An excess of water is better than an insufficiency, but it is important to carefully gauge the quantity so that just enough is used.

284. First yarn the joint as if for lead joint, driving up the yarn evenly as hard as is possible without forcing any of it into the pipe past the spigot end. This is the most important part of the work of making a cement point. The tightness of the joint depends on the yarn. The cement only holds the yarn in place.

285. Then nearly fill the joint with cement, carefully working it in with the tool all around the pipe.

286. Next drive in a strand of twisted yarn, large enough

to make it require driving with the yarning tool and hammer to force the yarn into the joint.

287. Drive up this yarn evenly all around the joint, using as much care to drive it home as if you were making a lead joint. The more the cement can be compacted the better will the finished joint be. The success of the cement joint depends upon the care with which the yarn is driven home.

288. Finish the joint by packing the remaining space with cement and pointing up the whole with the trowel.

289. In warm weather the completed joint must be covered over with wetted burlap, and the burlap frequently sprinkled with water until the cement has set.

290. Cement joints must not be subjected to pressure until they have set at least 24 hours; 48 hours is better.

WROUGHT IRON PIPE.

291. Prepare the trench with the same care as for cast iron pipe, except no extra depth is required at joints.

292. Remove the couplings from the ends of the pipes on which they were screwed at the factory, reverse the couplings, carefully clean the threads on the couplings and pipe and screw the coupling on the opposite end of the pipe. The object gained by this is, that should the threads exposed in shipment be damaged, the extra force required to make them up properly can be more easily applied when screwing up the couplings separately than when a whole length of pipe must be handled. It is also more difficult to make up two lengths of pipe than it is to screw a coupling on one pipe. Reversing the couplings leaves clean, bright threads to be made up when the pipes are coupled, and enables the work to be done easier.

293. Threaded joints must be made up until but one or two threads of a standard length thread are exposed. The joint will be the stronger if the threads are screwed up to the shoulder.

294. If a joint is making up tight before the threads are screwed together far enough, a few raps of a hammer upon the couplings while pressure is applied on the tongs will make the work easier.

295. Wrought iron pipe can best be made up on cross pieces

stretched over the trench. After several lengths are made up, the cross pieces are removed and the pipe lowered into place, care being exercised to keep debris from falling into the trench until the pipe is bedded solidly on the bottom.

296. In starting a screw joint with 4-in. pipe or larger, time can be saved by taking several wraps around the pipe, windlass like, with a rope, after the thread is started, and then making up the first part of the joint by pulling on one end of the rope until the tongs are made necessary.

297. The chief value of a pipe joint cement is a lubricant to overcome the friction when a joint is made up. Whichever kind is used should be sparingly applied on the threads of couplings, fittings, etc., to avoid dangerous accumulations inside the pipe.

298. In cutting wrought iron pipe, always remove the burr left inside the pipe by the tool.

299. After the joints in wrought iron pipes have been made up, the tool marks must be carefully painted over.

300. A thick coating of tar or other protecting compound must be applied to the pipe after it is lowered into the trench.

SETTING SPECIALS.

301. Specials and drips must always rest solidly on the undisturbed earth. Permanently tight mains are impossible if they do not.

302. Should you be careless enough to excavate too deeply for a special or drip, the filling must be cement concrete. No blocking of any kind may be used.

303. When specials for future connections are set on feeder mains, or mains which it will be difficult to bag off when it is desired to make connections, always lay a short piece of pipe from the opening in the special. Then when the connection is to be made, it will only be necessary to bag off the short pipe.

304. All openings in specials set for future connections must be closed with cast iron plugs with permanent joints.

305. All openings of any description put in mains for any purpose must always be kept securely closed when no work is being done requiring them to be open.

306. When it is necessary to reduce the size of the mains, proper reducing specials must be used.

307. When conditions require the use of a sleeve, the ends of the pipes to be joined must first be carefully covered with a collar of sheet iron, sheet lead, tin, paste board, or canvas. If sheet iron is used, it must fit closely to the pipes and the ends of the iron or tin must be carefully lapped. Any interstices between the pipe and whatever material is used for a collar must be filled with putty, red lead, cement or fire clay, so that the sleeve may be run full of lead. In fitting the sleeve, it must be centered on the pipes, so that each end is inserted an equal distance and the lead space is uniform around the entire circumference of the pipe.

308. Whenever it is necessary to use packing, as in fitting a saddle flange, only pure sheet rubber or sheet lead may be used, and the pipe and fittings must be carefully cleaned from dirt and oil.

DRIPS.

309. On important feeder mains, and on mains where a long stretch of pipe is to be dripped, only line drip pots may be used.

310. On small mains where only a short stretch of pipe is drained and very little condensation is likely to result, drips made of pipe are allowable.

A pipe drip for a 4-in. main should be as follows:

Tap the bottom of the main 1¼ in.

Connect a 2 by 1¼ in. tee to the opening with a short shoulder nipple.

Plug one side of the tee and run a 2-in. pipe from the other side to the point where the drip riser or stem is to set, pitching the pipe sharply away from the main.

Screw a 2-in. tee, bullheaded, on the end, letting the run of the tee stand vertically.

From the bottom of the tee run a leg of 2-in. pipe, at least 15 inches long, and as much longer as practicable, with a 2-in. cap closing the lower end.

Into the top of the tee screw a 2 x 1-in. bushing from the

under side of which a 1-in. pipe, long enough to extend within 4 in. of the bottom of the 2-in. leg has been screwed. The 1-in. pipe must project through the bushing at least 1 inch.

Connect the drip stem to the 1-in. pipe, extending through the bushing with a coupling, first wrapping several turns of lamp wicking soaked in red lead, around the 1-in. pipe on top of the bushing and then screw the coupling tight down on the wicking.

311. No piping smaller than 1 in. may be used on drips, either for stems or for any other purpose.

312. On drip pots the cover should be tapped for 2-in. pipe and the cover should be made up with a lead joint calked like a main joint.

Make up a 1-in. pipe long enough to reach within 4 in. of the bottom of the drip pot, through a 2 x 1-in. bushing, as directed for a pipe drip. Screw the bushing into the 2-in. opening in the drip pot cover. Run the drip stem with 1-in. pipe, as for a pipe drip, except that when the stem cannot be set directly over the drip pot, which seldom occurs, the horizontal pipe must be graded sharply to drip into the pot.

313. All piping set for drips must rest solidly upon the undisturbed earth.

314. Drip stems must be located at a uniform distance from the curb line, and a short 1-in. nipple should be screwed on the top end, so that when the thread becomes worn from pumping the drip, only the nipple need be renewed.

315. Drip stems must not project enough above the surface of the ground to cause pedestrians to trip over them.

316. Always report the installation of a drip separately, recording the character of the drip, its diameter and depth below the bottom of the main in which it is set, if it is a pot drip; the length, size of pipe and fittings used, if a pipe drip; a list of pipe fittings in the drip stem, and the exact location, illustrated by diagrams of the drip pot, or tap in the bottom of the main, if a drip pipe, and the drip stem. Also give the number of the house nearest to the location of the drip stem.

317. All piping for drips must be run before the main trench is filled in.

TESTING.

318. Before any joints have been covered up, all new mains must be tested to an air pressure of at least 5 lbs. and all joints carefully brushed with soap suds and examined, for leaks, while they are under pressure.

319. Bags and main stoppers will not satisfactorily withstand this pressure, so unless the new main starts from a valve a short piece of pipe must always be left out when a new main is started, in order that the end of the new line may be closed by a solid plug. When the testing is completed, the connection where the short piece of main is left out, is made.

REMOVING AIR FROM MAINS.

320. When gas is turned into new mains, the air in them must first be blown out through pipes set at the ends of the new mains.

321. During the blowing process, at least two men must work together, with one of them on watch to assist the other out of the trench should he show any indication of becoming gassed.

322. No fire or open flame may be allowed near the point where the air is being blown out, as for a part of the time a highly explosive mixture of gas and air is being discharged.

323. Provide a pail of soap suds and a piece of rubber tubing for making a test of the gas. When it is considered that the explosive mixture is all blown out, connect the rubber tubing to the blow pipe and allow the gas to bubble through the soap suds. By applying a match to the bubbles blown off, you can readily determine if the gas is explosive or otherwise, as if it is explosive the bubbles will explode when the match is applied.

324. When all the air is blown out at the end of the new main, open all of the drip stems along the main until all of the air is blown from them.

RECORDING LOCATIONS OF MAINS.

325. As each piece of main is laid, measurements showing the line on which it is run, its depth below the surface of the

street, the location of all fittings, and that of at least one bell in each block, must be made and recorded. On wrought iron mains, the length of each piece of pipe must be recorded.

326. The measurements showing the line along which the main is run may be taken from the nearest curb, if the street is paved. If it is not paved, the measurements must be taken from the property line.

327. The measurements along the line itself, giving the location of fittings and of the bells, should be made from a zero point, such a point being adopted for each city block. One of the property lines of the intersecting street makes a good zero point. Care must be taken to take the corresponding line for each block along each street, and as far as possible, for every one of a number of parallel streets, and to make all measurements in the same direction. Thus, on streets running north and south, the zero point must either be the south line, or the north line of the intersecting street in each case, not the north line in some cases and the south line in others.

328. If no cut lengths are put in between intersections, except immediately at the fittings, it is only necessary to locate the bell at which the full lengths begin and to make a note of the normal distance between bells.

329. If a cut piece is required at a distance from a fitting, the bell at which the full lengths again begin must be located.

330. This information as to the location of bells is valuable when the work of barring for leaks is undertaken, especially where the mains are laid under paved streets.

331. The measurements, giving the length of main laid, are taken from centre to centre of specials, and, of course, include the length of any specials in the line.

332. Report the main laid in each block on a separate sheet and make the measurements clear by showing them on a diagram sketch of the block.

333. Locations of the points where gas mains change grade must be carefully given. Knowledge of the location of the high points of a gas main is valuable, should a main become stopped.

SERVICE WORK.

334. Gas service pipes are the company's delivery wagons.

They are of such importance in giving good service to our consumers that no man who lacks a fine pride in doing good work will be permitted to run service pipes.

336. The same rules applying to main pipe foundations are especially applicable to service pipes.

337. From this it is evident that gas services must not be laid in sewer or water trenches that have been excavated deeper than the service trench, and so are liable to settlement after the gas pipe has been laid.

338. Before starting a gas service, plan out the entire service, so that you will see clearly how the pipe will run, and so avoid any obstruction which you might otherwise encounter.

339. If the premises to be supplied are occupied, notify the occupant of what you propose to do. If objections to the work are made, 'phone the office for instructions.

340. Before commencing the work, be particular to note any defects, such as cracked walls, defective sidewalks, broken windows, etc., for which there may be any possibility of blaming the service after the completion of the work.

341. Make a written note of such defects on the back of your service order and call the attention of the occupant of the premises to them before you start the work of laying the service.

342. Services must be run in straight lines at right angles to the line of the main pipe.

343. If it is necessary to offset a service pipe, make the offset with 45 deg. ells.

344. Start the service pipe so that it will not enter the building wall between two windows, or at any point where it is necessary that the full strength of the wall be maintained.

345. Whenever a service is run through a grass plot, burlap must first be laid to protect the sod, and the earth excavated must be deposited on the burlap.

346. The sod where the trench is to run must be carefully cut with a spade and placed along the trench just as it is removed, so that each piece can be replaced in the exact spot from where it was taken.

347. On paved streets the paving material removed must be piled back of the curb line in neat piles.

348. In every case the gutter must be kept free and no mail box, fire plug, fire alarm box, etc., must be obstructed during the progress of your work.

349. Grade the service trench up from the main pipe as sharply as possible and still keep the service pipe below the frost line.

350. If conditions require the grading of the service away from the main, do not proceed with the work until you obtain special instructions from the superintendent.

351. Unless conditions prevent, always tap the main pipe on the side. The deposit of borings inside of the main, when it is tapped on top, does its share towards reducing the main's carrying capacity. Be careful in setting your tapping machine to put it to correspond to the grade of the service.

352. To prevent accidents, three men must always work together when a gas main is being tapped, one man keeping watch on the top of the bank.

353. Service men must not attempt to tap mains, or make up joints under pressure, where they will be compelled to work under overhanging banks, or where a free circulation of air is difficult, unless they are working under the special direction of the superintendent. Working in such places under such conditions is very dangerous, and is forbidden, except as above noted.

354. 1¼-in. pipe is the smallest pipe which may be run.

355. 3-in. mains may not be tapped larger than 1-inch pipe.
4-in. mains may not be tapped larger than 1¼-in. pipe.
6-in. mains may not be tapped larger than 1¼-in. pipe.

356. Mains smaller than 3 in. must be cut and tees inserted.

357. When it is necessary to make openings in 3-in., 4-in. and 6-in. mains larger than the sizes given, the mains must be cut and proper tees used, or proper saddle flanges must be used.

358. Make the first piece of service pipe laid, a short piece, not over 4 ft. long. It will be easier to start, and there will be less danger of starting it cross threaded.

359. Reverse the couplings on service pipe, as per instructions given for laying wrought iron mains.

360. Stand each length of pipe on end before coupling it

up and while upended, rap it sharply with a hammer to free it from scale, rust, etc.

361. Look through each pipe before using it.

362. Screw up each joint until the whole thread is entered in the coupling or fitting.

363. Always ream out the burr left on the inside by cutting off tool.

364. Test each joint, with the gas pressure on, with soap suds applied with a brush.

365. As each piece is screwed up, carefully paint over tool marks, and as pipe is laid in trench, carefully apply a thick coat of tar or other protective covering.

366. If the soil contains ashes, protect the service pipe with a thick coating, at least 1 in. thick, of cement mortar, three parts sand to one of cement.

367. In cutting the hole through the building wall, do not cut away any more than is necessary to introduce the service pipe and protector.

368. Cement the service protector (a wood casing to cover the pipe from the inside face of the wall to a distance of ten to twelve inches beyond it outside) thoroughly into the wall, both inside and outside. Also fill the space between the service pipe and protector solidly with cement; to make the wall as impervious to water as before the service was laid.

369. Never take chances for tapping a service pipe by driving it, unless conditions make it impossible to get the service in otherwise. A small tunnel, bored or made with a tunneling bar, must always be made in preference to driving the pipe, as only then can you be certain that the service is properly graded.

370. Always tunnel under gutters and sidewalks unless conditions make it impossible.

371. If a curb box is used, the box must be set to come just inside the curb line. The cock must be set so that its plug will be plumb, and the box must be centred carefully over the cock, with the earth rammed solidly around it to hold it into place.

372. A gas company is known by the manner in which it leaves its service trenches.

373. Some service men seem to think that they have done their full duty when the service pipe has been carefully laid, and that there is no necessity of carefully refilling the trench. You must, however, always remember that to give satisfaction to our consumers in all of the work we do for them is fully as important as to deliver good gas to them. Realizing this, and the pride most people have in the appearance of their homes, the necessity of carefully refilling every trench dug for the company, so that it will never show up as a monument of indifferent work, will be clear to you.

The service man that cannot run a trench through a lawn and leave it in such shape that a month's time will remove every trace of his work, is unworthy of the name.

374. Every bit of earth taken out of a service trench must be rammed back into place, to make the surface of the completed trench flush with the ground through which it runs.

375. Any sidewalk, driveway, etc., which may have been disturbed, must be carefully replaced in the same condition in which they were found. If this is impossible, make an immediate written report to the superintendent, stating clearly what must be done to place the premises in the same condition as when the service was started.

376. All debris must be carefully swept up and removed from the premises when a service is completed.

377. Service trenches should not remain open at night. Should conditions, however, compel a trench to be left unfilled, carefully barricade it and protect the opening with lights. A few minutes spent in taking this precaution will insure against paying or fighting claims for damages.

378. In refilling a service trench on a paved street, when the pavement is not immediately replaced, temporarily pave over the opening, so that it will offer the least possible inconvenience to traffic until the pavement repairs are permanently made.

RECORDING LOCATION OF SERVICES.

379. Make a separate report on each service pipe run and make your measurements clear by means of a diagram.

380. Give in every instance the following data :

1. Size of pipe. Location and size of tap in main.
2. Total length of pipe laid, taking measure after pipe is laid in trench.
3. Distance from main to curb; from curb to property line; from property line to wall of building, or, when service pipe does not run directly into the house, from property line to fitting set opposite where service enters wall of building.
4. Length of pipe run inside of building.
5. Distance from center of pipe to property line of nearest intersecting street, taking measure along curb or property line and distance from pipe to nearest lot line of adjoining property.
6. State whether service pipe grades to main into building and give location of any tees left for adjoining premises.
7. Show points of compass on your sketch or diagram.

PLUMBING DRIPS.

381. Drip liquor must never be pumped into a gutter or catch basin. You must carefully collect it and take it to some locality where its odor will not create a nuisance.

382. Pump every drip dry. Never leave a drip where you have any doubt about this, without making a written report concerning its condition and then see that this report is properly forwarded to the superintendent. Keep a record of the amount of liquor pumped from each drip.

383. If a drip pipe needs repairing, or, if it is in such condition that pedestrains are likely to stumble over it, make a written report of the conditions and see that it is promptly sent to the superintendent for action to remedy the matter.

STREET REPAIR WORK.

384. Repairs to mains and services must be so promptly and carefully made that no loss will result to the company from damage caused by escaping gas or improperly filled trenches; no annoyance will be caused to consumers from interference with their supply of gas; nor any inconvenience

suffered by the general public from the obstruction of traffic in the street.

385. Such repair work must be carefully done that when the work is completed, no further complaint will arise from the cause of the repair.

386. Before proceeding with any repairs requiring the opening of a street, always ascertain if the necessary permit has been secured from the proper city authorities. In case, however, of urgent need, such as a serious leak, proceed with the work first and get the permit afterwards. Each foreman on street work must make it his duty to see that the proper permit is secured for any emergency street work he undertakes.

387. Never bar for leaks where there is any possibility of damaging any underground structure, such as a conduit, water pipe, etc.

388. Never use a light or open flame about street repair work.

LOCATING LEAKS IN MAINS.

389. When looking for a reported leak, first hunt for any recently completed excavations in the street. If there are any, bar the main carefully at the point nearest such recent excavations.

390. In every case of a leak complaint in the street, you should secure the locations of the mains in the locality from which the leak is reported, before proceeding with the work, unless the leak reported is a serious one, in which event the point of leakage can usually be quickly found without having the main locations.

391. When gas is found escaping from sewers, or manholes, a careful inspection of the sewers, or conduits connected to the manholes showing gas, will indicate where the most gas is escaping and so assist in locating the point of leakage.

392. While it is always of the greatest importance to insure that every consumer has gas when he wants to use it, in case of a hidden break difficult to locate, and resulting from extensive excavation, as when a main sewer is being built, prompt action must be taken to cut off the gas from the main

affected. In such a case, should no valve be convenient, immediately uncover the main on both sides of the break and bag off the broken section; then proceed to locate and repair the break.

393. Leaks in the street must be carefully, promptly and persistently followed up until located and repaired.

394. In abandoning old mains, carefully close with cement all open ends of pipes which have been uncovered.

395. Always, when cutting off old services, cement up the ends of the pipes remaining in the ground. Should a leak ever afterward occur in the street, it will then be impossible for the gas to follow through old mains and services and appear in unexpected places.

396. Whenever any repair work requires you to cut off gas from a section of main, ascertain what consumers' supply will be affected and notify them, stating how long the gas will be shut off.

SETTING METERS.

397. The indifference with which many fitters seem to treat our gas meters is responsible in a large measure for the popular distrust of them, and for the opinion prevalent among a few of our consumers, that a gas meter is but a tin case with a fan arrangement inside to work the counter. Surely, they argue, a piece of mechanism which is often set almost as though it had been thrown into the house from the street, and coupled up wherever it chanced to land, is considered of very little value by the Company which owns it.

398. Every gas man knows, and you should know it, too, that as a measuring machine, the gas meter has a far better record for accuracy than any other measuring device in commercial use. Knowing this, give our gas meters the respectful treatment which their long record of faithful service has earned for them.

399. A gas meter represents a considerable sum of money, and every precaution must be taken to prevent the waste or loss of this money from damage to the meter.

400. Meters must always be set in dry places, properly supported, set level and plumb, with no part of the case

touching any cement, brick or stone wall, or pavement, and where they will not, so far as is possible, be exposed to great fluctuations in temperature.

401. You must never set a meter on the floor, in a coal hole, under a window deck, in any place where it can be damaged by having anything thrown upon it, or where it will be so high that the meter reader must get a ladder to take the statement, or where it will be exposed to freezing.

402. You must always bear in mind that, as our meters must be visited to secure the statement at least once a month, they must be set where they will be easily accessible. It is a part of the consumer's contract to furnish such an accessible meter location. If he does not do so, you are not to set a meter for him until you receive instructions from the office.

403. In setting a meter in a meter room where there are several risers, locate the proper riser by closing all of the keys, except one, on the fixtures in the premises the meter is to supply. Place a piece of paper over the burner at this key, and then blow through the risers, one at a time, until you blow the paper off, which will, of course, indicate that you have found the riser you want.

404. Never kink or flatten lead meter connections. This is an unpardonable offense.

405. Always watch the test hand of a meter at least 10 minutes, with no gas being used, to ascertain positively that the piping connected to the meter is tight. No excuse will be accepted for your failure to take this important precaution.

406. If such a test shows the gas piping to be leaking, do not set the meter, but remove it to the shop, noting the reason for your not setting it on your order.

407. Always light up all the burners supplied through the meter and note whether the meter is supplying the proper amount of gas. This is just as important as the test for leakage. If necessary, take pressures with a pressure gauge, with all apparatus in use.

408. Always note on your order *on the job* and *after* the meter is set, the number of the meter, its statement, and a complete list of all of the burners and apparatus connected to it. This, also, is most important.

409. To determine the size for a gas meter is largely a matter of judgment, as no hard and fast rules may be laid down to govern all cases. Sometimes, on a larger job, but one or two gas burners will ever be used at the same time, and in such cases a meter large enough to supply sufficient gas to all of the burners connected, should they all be used at the same time, would be a waste of money.

Generally the following table will apply:

MAXIMUM WORKING CAPACITIES OF GAS METERS.

	Cu. ft. per hour.
3-light	60
5-light	90
10-light	120
20-light	180
30-light	270
45-light	360
60-light	420
80-light	510
100-light	600
150-light	900

The above capacities are for a drop of 5-10 in. pressure between the inlet and outlet of the meter, for the average capacities of a number of meters of different makes.

410. If conditions are such that this drop in pressure cannot be permitted, use a meter of next larger capacity than the rating required by the apparatus to be supplied. In case of doubt, report the matter to the superintendent for special instructions.

411. When determining the required size of a meter, rate the apparatus to be supplied as follows:

	Cubic feet per hour.
Open flame burner, each	6
Mantle burner, each	5
Arc lamp, per mantle, each	5
Top stove burner, each	15
Oven burner, each	15
Circulation water heater, depending on size, each	30-60
Instantaneous water heater, each	100
Gas grate, each	35
Gas heater, each	25-50
Gas engine, per horse power per hour, each	30

412. Never set less than a 5-light meter for a gas stove.

413. Never set less than a 10-light meter for an instantaneous water heater.

414. With a little attention given to a study of the greatest amount of gas that the meter will be called upon to pass at any one time, you will have no difficulty in selecting the size meter required. In cases of doubt, be on the safe side. It's better to set too large a meter than to risk a complaint from a consumer.

415. Always, when setting a meter, teach the consumer to read it, if you can persuade him to take the time, and tell him the statement of the meter you are setting for him.

416. When removing a meter, always remove the lead connections at the same time and permanently cap the service pipe.

417. Always note on your order the address to which the consumer is removing, if you can obtain it when removing a meter.

SLOT METERS.

418. Never set a slot meter where it cannot be absolutely controlled by the consumer it supplies.

419. Slot meters must be set inside the consumer's premises, never in a hall, meter room, or basement, to which other people than the consumer, have access. You will be held responsible for any loss occasioned by your failure to observe this rule.

420. Always set slot meters so that the slot mechanism will be within easy reach of the consumer.

421. When you have set a slot meter, always have the consumer insert the first coin while you are present.

422. Carefully explain to him how to handle his slot meter, and how to check up the gas received for the money he puts into it, before you leave the job completed. This can be easily done by noting the meter statements and ascertaining the amount of gas delivered for any given sum of money deposited in the meter.

423. Be especially careful, if the meter supplies light in

different rooms, to warn the consumer never to place a coin in the meter when the gas purchased by the previous coin has been entirely used, without first positively ascertaining that no jets have been left open.

SETTING GAS STOVES AND FUEL APPLIANCES.

424. Careless work in connecting gas stoves and fuel appliances will contribute more to render their operation unsatisfactory than any other one thing.

425. You must fix firmly in your mind that the first requisite in this work is quality, next low cost. The least possible cost of the work must always be aimed for, but, if necessary, the most must be sacrificed for quality of work.

426. All piping must be run in straight lines, always parallel to the lines of the building walls; rigidly supported by proper supports spaced not more than 10 ft. apart, and all vertical lines must be plumb. All turns must be made with either tees, elbows or 45 degree ells, except short offsets, which may be carefully bent.

427. All piping must be carefully graded and plugged tees set at all low points, so that should it collect, condensation may be removed from the piping, with the least difficulty.

428. The burr left on the inside of the pipe by cutting off tools, must be reamed out to leave the full bore of the pipe.

429. Use no unions; make all connections with either right and left couplings, or long screws.

430. Use dope on pipe threads sparingly. Its use is more to lubricate than to cement over defects

431. You must take pride in having your completed pipe work appear as well as any plumber or expert pipe fitter could make it.

432. Learn before starting your work, the amount of gas which must be supplied and install your piping of sufficient capacity to carry the required amount of gas at the full pressure to each appliance, when it is all in use at the same time.

433. Plan your piping in accordance with the following table:

CAPACITIES OF GAS PIPE AND GREATEST LENGTH PERMITTED.

Diameter, inches.	Length, feet.	Capacity per hour, cubic feet.
3/8	20	11
1/2	30	22
3/4	50	60
1	70	127
1 1/4	100	222
1 1/2	150	349
2	200	718
2 1/2	300	1,253
3	450	1,977
4	600	4,059

434. Use the next size larger when the length in the table for a given capacity must be exceeded.

435. Never run a fuel line smaller than 3/4 in.

436. Never run a supply pipe to a gas engine less than 1 in.

437. Always make a run of pipe for a hot plate of 3/4 in. pipe unless you are sure that hot plate will never be replaced by a gas stove.

438. Always, in determining the size of pipe to be run, follow the table for gas consumption of various apparatus, given under instructions for setting meters.

439. Ask for special instructions when you are running piping for special fuel apparatus.

440. Never cut holes through walls, floors, or partitions, any larger than is necessary to take the gas pipe.

441. Upon completion of your work, you must always carefully cement all openings which you have cut in walls to run your pipe.

442. When your apparatus is all connected up, light all the burners to ascertain positively that an ample supply of gas has been provided. Negligence of this precaution is a crime.

443. Adjust every burner to take the largest possible supply of air without lighting back. When the apparatus is exposed to sharp drafts, too close an adjustment must not be attempted, or complaints from lighting back will surely result. A properly adjusted burner will show a hard green cone in the centre of each jet of flame.

444. Be sure that your piping is tight.

445. Before leaving the work completed, make absolutely certain that the surrounding woodwork is completely protected from danger of scorching or catching fire. When gas stove or heater flues terminate, so that the products of combustion will impinge upon wood, a deflector of sheet metal or asbestos must be put up.

446. All water heaters must be provided with a flue pipe to carry off the products of combustion.

447. When a gas stove oven is connected to a flue, the flue pipes must be fitted with a damper, to prevent a strong draft from drawing an excess of cold air into the oven, or else an opening must be left in the flue pipe to by-pass the oven. The object to be attained is to prevent waste of gas by passing too much cold air through the oven. If the gas stove is fitted with a hood, the best flue pipe arrangement is to connect the hood to the chimney and discharge the flue pipe from the oven under the hood.

448. You must always explain to the consumer, or the person who is to use the apparatus you are connecting, just how the apparatus is to be handled, showing him how to light it and dwelling especially on the necessity for regulating the amount of gas burned to the quantity of work to be done.

449. Be sure to have the consumer understand that he is to telephone us *at once*, if he has any trouble whatever in handling his apparatus.

PIPING HOUSES FOR LIGHT.

450. Sizes and lengths of pipe and greatest number of ⅜-in. openings allowed:

Diameter of pipes, inches.	Greatest length allowed, feet.	Greatest number of ⅜-in. openings allowed.
⅜	15	1
½	30	3
¾	60	10
1	70	15
1¼	100	30
1½	150	60
2	200	100
2½	250	200
3	300	300

If above lengths of pipe are exceeded, use next larger size of pipe.

451. Do not run pipe smaller than 3/8 in.

452. Risers must not be less than 3/4 in.

453. Run gas pipe supplying storerooms full size up to last opening.

454. Locate risers so that meters will not be placed in coal holes, under the decks of windows, on outside basement walls, nor exposed to extreme heat (as near furnace or steam pipes), dampness, frost, or where they are likely to be damaged from any cause.

455. Risers must also terminate where meters will be easily accessible.

456. In flats or buildings containing two or more flats, or stores, where no meter rooms can be provided, terminate risers so meters can be set in the basements of the respective premises to be supplied, but arranged so as to require the least amount of service extension to reach them.

457. When two or more risers are run to meter rooms, they must be spaced not less than 15 in. or more than 24 in. apart where meters are to set.

458. Extend all risers to location provided for meters.

459. Run all risers in inside walls, where they will be protected from frost. Vestibule walls shall be considered outside walls.

460. Risers must not extend through basement ceilings more than 1 in. and then must be run in such a manner that furnace pipes, etc., will not prevent their being extended to meter locations.

461. Properly grade all gas piping to drip to risers and securely support it with braces, straps, gas hooks or hangers, to prevent sags or pockets. Every horizontal pipe must be securely supported at points spaced not over 10 ft. apart for pipes 3/4 in. and larger, and not over 6 ft. apart for 3/8 and 1/2-in. pipes.

462. When building conditions make it impossible to avoid trapping a gas pipe, set a tee with a nipple and cap, for a drip, at the bottom of the trap, and so arranged that it will always be accessible to remove condensation.

463. Take especial pains to remove the burrs left on the inside of gas piping by the cutting off tool.

464. All drops left for lights must be arranged and secured so they will not screw out when fixtures are taken down. They must project at least 1 in. and not over 2½ in. beyond the plaster, and they must be rigidly secured either to the floor joists or to cross pieces nailed between joists.

465. Every drop must be tried to insure that the thread on it is straight and the drop secured so that the fixture attached to it will hang plumb.

466. Side lights must be supplied from risers run from pipe run in floor below lights, not dropped from above, except in case of basement lights. Every side light must be so rigidly fastened in place that it will not work loose with the use of the fixtures attached to it.

467. Do not run gas piping on bottoms of floor joist, where it will be plastered in, unless the flooring is to be laid double thickness, with the first thickness laid diagonally across the joists.

468. Arrange the piping so that all notches necessary to be cut in floor joists will come near points where joists are supported.

469. Be especially careful to arrange your gas piping so no broken pipes will be likely to result from any settlement of the building.

470. In remodeling or extending old gas piping, make connections to make sizes and lengths correspond with tables given. Do not make extensions from small pipe. If necessary, run new riser from meter.

471. Run all gas piping for fuel apparatus independently of piping for lights, carrying a separate riser to the meter location, so that a separate meter may be set to register gas used for fuel, if necessary.

OLD HOUSES.

472. Arrange piping so that as much of the job as possible can be run in between joists and parallel to them, so that the least possible amount of flooring need be taken up.

473. Carefully remove flooring to open pockets where each

drop is to come. If necessary to prevent splitting, saw off tongues with compass saw before attempting to take up floor boards. Saw across floor boards only at joists, and make saw cuts with a long slant, so that top of cut will come in centre of joists, while bottom of cut will clear its edge. Then when floor is replaced, if pasteboard is used to fill up the space left by the saw cut, no complaint will arise from loose boards.

474. Be careful in cutting holes in plastered ceilings and walls to arrange them so that the ceiling or wall plates of fixtures will cover them when the work is completed.

475. All drops and pipes for side lights must be rigidly fastened into place.

476. If the side light piping cannot be secured without removing more plaster than the wall plate will cover, hold the piping in place by using a large flat wall plate and a piece of casing on the nipple which comes through the wall plate, with the casing cut long enough so that when the bracket is screwed tight it will clamp the gas pipe tight to the lath and plaster.

477. Unless the consumer orders otherwise, hang gas fixtures in dining room 6 ft. high from bottom of fixture to floor; in other rooms 6 ft. 3 in.; in halls 6 ft. 6 in.; and all side lights in bedrooms 5 ft. high, in hall 6 ft. high.

TESTING.

478. Upon completion of each gas fitting job, test it with an air pressure of 3 lbs., or 6 in. of mercury. Do not consider the job tight unless it will hold this pressure 30 minutes without any drop.

INSPECTING GAS PIPING.

479. Carefully examine all piping to ascertain that it is run in accordance with the foregoing instructions and that the lengths, sizes and openings correspond with the tables given.

480. Note if the risers have been extended to the location provided for the meters and if this location is suitable for the meters and can be easily reached with the gas service.

481. If these conditions have been met, put on your pump and gauge and apply the pressure test.

482. If the job is not tight, or, if it is not properly run

in accordance with the above instructions, note the faults in detail on your inspection order.

GAS ARC LAMPS.

483. To provide for the successful operation of gas arc lamps, the following sizes of pipe must be used. No pipe smaller than ½ in. must be used except for drops.

For one lamp use	½ in.	pipe for	a run of	less than	30 ft.
" 2 to 3 "	¾	"	"	"	" 50 "
" 4 to 6 "	1	"	"	"	" 70 "
" 7 to 10 "	1¼	"	"	"	" 100 "
" 11 to 20 "	1½	"	"	"	" 150 "

484. If the lamps are being hung on an old line of pipe. carefully blow it out with a pump before putting up the lamps

485. Local conditions will in every case govern the height the lamps are to be hung from the floor, but 8 ft. is the proper height.

486. Adjust the pilot light so that the flame will immediately light the mantles when the chain is pulled, and the pilot flame is about ⅜ in. high when it is not in use.

487. Do not attempt to regulate the gas supply to the burners with the needle valves, as they are intended only for cut-offs, not regulators. If regulation is required, secure new nozzles to accomplish the regulation.

488. Neatly bronze any pipe used in extending the drops for the lamps, or else, on the best work, case the drops with gas fixture casing and use a sliding canopy to make a finished job at the ceiling.

489. Outside arcs must be carefully suspended and the gas piping supplying them must be protected from frost, either by a suitable protection covering or by running the gas supply pipe inside a larger pipe.

490. If outside arcs are suspended from lamp posts and are intended for use in winter, make the risers of 1-in. pipe and arrange the supply pipes in the ground so that they will be below the frost line and be graded sharply enough to drain off the condensation which will drip into them from the risers.

491. Our meter statements must be secured in the shortest possible space of time, but accuracy must not be sacrificed for speed.

492. When taking statements, you must remember especially our policy in handling our consumers. We want you to show them by your manner that you, as our representative, are fully alive to the value of their business, but we don't want you to waste valuable time visiting with them or attempting to handle any of the business with which you are not concerned.

493. If a consumer wants the statement of his meter, give it to him at once, but do not attempt to figure his bill.

494. If the consumer has a complaint to make, note it down for a report when you return to the office.

495. If he desires any other information or service, refer him as considerately as you possibly can to the office, where his wants will receive careful attention.

496. Always record the meter statement while you are at the meter. Do not attempt to carry it in your head until you are outside the building.

497. Do not strike matches or carry open flames in basements filled with rubbish. You cannot be too careful in this respect. A very small fire would more than pay the entire expense of reading all of our meters for a month.

499. Do not attempt to force your way into vacant premises or premises where the occupants are away.

500. Remember that every man's house is his castle, and you have no business entering it except with his consent.

501. Keep your eyes open for meters damaged in any way, meters improperly set, not supported, etc., and make a written report to the superintendent of all such cases.

502. Report your statements to the office at the close of each day's work.

503. When delivering bills, always be sure that the right bill is left at the right place. Nothing will more quickly arouse a consumer's suspicion of the accuracy of our methods than to receive a bill which belongs to his neighbor. He will

almost argue that it is just as easy for the meter reader to get mixed in taking meter statements as it is for him to deliver the wrong bills.

504. Always leave a consumer's gas bill where he will get it. If there is no mail box, shove the bill under the door. Each gas bill has cost us a certain amount of money to make out, and any carelessness in delivering bills will surely result in loss to us and annoyance to our consumers.

COLLECTION OF DELINQUENT GAS BILLS.

505. It requires as much ability and application to make a successful collector as to attain success in any other line of work. To collect delinquent gas bills requires more ability than to collect other bills.

506. The skillful gas collector owes his success more to his state of mind than to any other one thing. He is so convinced of the value of the service covered by the delinquent bills and is so earnest in carrying on his work that his manner subtly impresses the people with whom he deals that he is there for business, and his expectant attitude of immediate payment for the bill he presents saves much tiresome argument. He knows that the accounts he is collecting represent an expenditure of the company's money for the benefit of the delinquent consumers, and that in asking payment he is requesting no favor, but only a return of the money which the consumers have been using thirty days or longer.

507. A gas collector must be aggressive and a pusher, but he must also have sufficient grip on himself and his work, so that he will not make enemies for the company in making his collections. The collector who antagonizes consumers from whom he collects is a losing proposition, even though he does get the money.

508. A successful collector must be a judge of humanity. Some people must be coaxed to pay bills they owe; others must be bluffed into doing so—no two can be treated alike.

509. You must be able to decide if a consumer, trying to stand off payment on a bill with a hard luck story, is telling the truth, or is just sparring for more time from a natural

disinclination to inconvenience himself by making a payment at once. We wish to give considerate treatment to such of our consumers in unfortunate circumstances who deserve it, but you must bear in mind that the success of the business demands the prompt collection of all money due us for services rendered.

510. While, strictly speaking, consumers complaining on account of delinquent bills, are not entitled to much consideration, as such complaints should be made at the company's office during the discount period, a gas collector must give them some attention.

511. You must, therefore, know just how the company handles its consumers' business, and how many checks it places upon its work to protect them from any overcharge.

512. You must be posted upon the gas meter's long record for accuracy; know that its accurate registration, when it has been proved by the prescribed simple method, is backed up by the laws in nearly every country where gas is sold, and that where there are public meter inspectors, such an inspector's certificate of proof of a gas meter is sufficient evidence to collect gas bills by process of law.

513. You must also know that no other retail business handling the volume of work that we do shows such a small percentage of errors.

514. You must be able to explain to complaining consumers why an error in reporting the statements of their meters does no injustice to them, and also how the meter shows the total amount of gas delivered to them since the day they began using gas through it, so that the difference between the last statement entered on the ledger and the statement when the meter was set must always balance the total sum of all the gas charged to the consumer through his meter.

515. This explanation shows how our meters give us a mechanical check upon the accuracy of our charges, which is independent of any possibility of clerical errors.

516. You must be able to show your consumers how they can check their own gas bills, by taking their own meter statements, just as they can check anything else they purchase. Gas meters have a far better record for accuracy than any

other measuring device in commercial use, and you should not hesitate to announce it whenever you have the opportunity.

517. There is no more reason for gas consumers asking us to explain how they have used the gas we have delivered to them, than there is for requesting their grocer to account for their purchases from him. If they will not take the time to check their purchases of gas from us, as we deliver it from day to day, they have no ground for disputing our bills. Consumers who regularly, at frequent intervals, read their own meters, never have to complain of excessive bills.

We are always ready to remove and test any meter, upon request from a consumer, and to investigate carefully the condition of his piping and apparatus. Consumers owe it to us, however, to make their complaint before their disputed bills become delinquent.

518. You need every bit of information you can gather about our business methods, so that you can meet the many hostile criticisms which will be made to you, in handling your collections. Every day's work should add something to your knowledge of ways and means to make your work more efficient.

519. Endeavor to settle the objections of complaining consumers at the first call. Use the telephone, if necessary, to secure information from the office concerning a disputed account. Next to patience and persistence, a gas collector's greatest need is the do-it-now spirit.

520. If your consumer cannot make you an immediate payment, never fail to get a promise of a definite date of payment, and make the date as early as you can.

521. Note the date on your bill and run a tickler file, in which you file by date the promises of payment made to you, whether the consumer is to call at the office or you are to call on him. Consult the file each morning, before you begin your day's work.

522. Never accept a date of future payment without making every effort to secure a small payment on account. Make it your policy to make every visit produce some cash. If you can't get a large amount, take all you can get, but make it a point to get something to show for your visit.

523. Endeavor to bunch your promises of payment for consumers in the same locality, so that you can route your work to make as many calls as possible in the same territory.

524. Be on hand on the date for which a promised payment is made. Being punctual on your part will go a long way towards producing a similar promptness of the delinquent consumer, and will assist you very materially in increasing the efficiency of your work.

525. A collector's work must be judged by the results he secures, and in these results the total amount collected is not to be considered as much as the amount which he does not collect.

526. Make every effort to locate the present addresses of delinquent consumers who have removed. A few inquiries of the neighbors will usually produce the desired information. If they do not, endeavor to learn where and by whom the delinquent consumer was employed, and make your inquiries there.

527. Do not hesitate to do a little detective work when you have the opportunity. Note on your bill all of the information you can secure concerning the delinquent consumer you are following up. You cannot get too much, for the knowledge we can secure concerning such people will either assist us in enforcing our collections, or it will be of value in preventing further loss from the same people.

528. Keep your own personal cash book, in which you enter under a heading representing the date, the name and amount of each collection.

529. When turning in your cash, foot up your cash book and have the cashier endorse his receipt for the amount you turn in, on your book. This will protect you should any dispute arise concerning payments made to you.

530. Report to the cashier each day's collections at the close of each day.

531. Hard work, mixed with brains, will produce as great results in our collection department as in any other. If you think that your work is done when you have simply asked for the money due us, get rid of the notion at once.

The percentage of gas consumers who can not be induced to

pay delinquent bills, if proper effort is made, is very small indeed. Make up your mind, then, when you are collecting, that you are going to get the money; if not now, then some time *very* soon, but be confident that you are going to get it, and don't be afraid to show your confidence in your ability to get it. Constant dropping wears away stones. A persistent collector, patient and sure of himself, will keep many, many dollars of the company's hard earned profits from disappearing in the loss side of our profit and loss account.

532. When it becomes necessary to cut off a consumer's gas for non-payment of bills, secure the amount of the delinquency and the last statement of the meter before proceeding with the order. Get access to the meter by stating that you have been sent to make an inspection. Carry out your order, noting the statement of the meter and figuring the bill for gas used since the last statement was taken. Then notify the consumer of your action and request payment for the total amount of the delinquency, including the gas used since the last statement. If you can secure payment, turn the gas on again.

533. Should a consumer refuse you access to the meter and so prevent your carrying out your order, advise him that you will dig up his service if you cannot get access to the meter, and that he will be obliged to pay the cost of the work before he can again secure gas.—J. M. Robb, O. G. L. A., 1906.

Report of Committee on Electrolysis.

See Second Day, Afternoon Session.

First Aid for Persons Overcome by Gas.

See page 189.

Report of Committee on Standard Sizes of Cast Iron Pipe and Specials.

See Proceedings American Gas Light Association, 1898, Vol. 15, pages 75-91; 1905, Vol. 22, page cxxxiii.

THE PRESIDENT: Gentlemen, we have listened to this report of the Board of Revision, and I think that this book speaks for itself. This, in my judgment, is a right beginning, and, if the work is continued, will give a text-book which will be of great use to the young men of the gas profession. Gentlemen, what is your pleasure?

DR. HARROP: Mr. Chairman, may I ask you to ask Mr. Stone if he will run briefly through the part of this report covering the mechanical side of distribution? Mr. Stone had charge of that part of the work. I think if he will do that, it will give the members a much clearer idea of the ground that is covered.

THE PRESIDENT: Mr. Stone, will you please come forward?

MR. STONE: Mr. Chairman, it will be impossible to read this. As you see, it is quite a book. It would be a physical impossibility for a man to read it within the time which we have to give to it. There is really nothing that I can say.

THE PRESIDENT: Dr. Harrop suggested, Mr. Stone, that you simply go through the pamphlet, and if there is anything that would be of interest to bring out some new thoughts, it would be a good plan to call it to the attention of the members.

MR. STONE: Well, Mr. President, I might say in regard to the report that it is intended for the use of men who know little or nothing about the laying of pipes or putting in the distributing system of a gas works or gas plant, and one of the hardest things that we had to decide was how much to put in and how much to leave out. That is, how much detail should go into the book. Of course, there are some things here that you and I would say are useless to us because we know them; but, on the other hand, there are lots of men in the business that do not know many things that are apparently simple to you or me.

Mr. Stone then gave a synopsis of the subject covered by the report, after which he said:

And then, in addition to this, if this was to be a complete

book on gas distribution, there should be added instructions for gas distribution employes, such as that contained in the volume gotten out by *Mr. Robb. Also a Report of the Committee on Electrolysis, and a report of the Committee on Standard Sizes of Cast Iron Pipe, such as that made to the American Gas Light Association in 1898 and 1905. Also the booklet issued by the United Gas Improvement Company in 1905, giving instructions on first aid for persons overcome by gas.

It was intended to treat the mechanical part of the business, especially that on distribution, as thoroughly as we could. There are a whole lot of things that we have left out, and probably some of the things that we have put in might have been left out. There are some things on which we might not agree. We may have different opinions in regard to what is the best practice. We simply did the best we could in the time we have had. (Applause.)

DR. HARROP: Mr. President, I would like to say a word further on this publication. As you know, this was originally an undertaking of the Ohio Gas Light Association, and it was brought into the Institute as a legacy from the Ohio. We made up our minds to publish the section on Distribution of Gas because that was in better shape than any of the others, and because we felt that we could complete it in time and make a better piece of work of it than any of the other sections. I do not think it will be taken amiss if I ask that the Institute express its opinion of this work as it has been reported upon today. It depends entirely on the position that the Institute takes with regard to this work whether it goes on or not. The pamphlet before you was published at the expense of Mr. Stone and myself. The total cost was $176, making it a matter of somewhat less than $90 apiece, and so far as that goes, we do not feel badly about it; but I think, to speak plainly, that it must be evident that unless the Institute takes hold of the revision work, and either entrusts it to us or gives us the authority to go ahead with it, and gives us ample financial assistance, it will be very disappointing to us, who have worked on the matter so far and have put so much time

*For these reports see pp. 518 and 583.

and effort into it. I would, therefore, like to ask that the American Gas Institute express its opinion one way or the other on this work as represented by the report of the Board, and tell us whether we shall go ahead or not, and either give us the authority, or delegate the authority to some officer, or to some committee of the Institute, to put the revision through. If we are to continue it, then we think we should have the financial assistance we need for handling the work and put it in position to meet the various demands that necessarily come up in the publication of such a work.

MR. DONALD McDONALD: Mr. President, I move that the Institute present to this Committee its thanks for this report, and that we request these same gentlemen to continue to serve through one more year with this work, and that the Treasurer of the Institute be instructed to pay the cost of printing this report.

Motion seconded.

THE PRESIDENT: Gentlemen, you have heard Mr. McDonald's motion. All in favor signify by saying "Aye." Contrary minds, "No." The motion is carried.

The next thing is—

MR. DOHERTY: Mr. President, just one word in connection with this before we pass it. The last question box publication was presented at the March meeting of the Ohio Gas Light Association. At that time the editor resigned. I think that the work ought to be continued by the American Gas Institute. I would, therefore, move that an editor be chosen or appointed to carry on the work, and that the expense of the work be borne hereafter by the American Gas Institute, the matter of expense to be in the hands of the Governing Board. Personally, I cannot undertake this work if it is continued.

Motion seconded.

THE PRESIDENT: Gentlemen, you have heard the motion of Mr. Doherty. What is your pleasure?

DR. HARROP: Mr. President, I certainly hope before this matter of the report of the Board of Revision is closed, that

there will be an expression of opinion by the members on its work.

MR. WALTON CLARK: I think that is shown by Mr. McDonald's motion.

MR. WALTON CLARK: Mr. President, Dr. Harrop has stated that he would like to obtain an expression of opinion with regard to the report, but it seems to me, Mr. President, that there can be but one opinion on the character of the work. It certainly is excellent, and we cannot too heartily thank Dr. Harrop and Mr. Stone for what they have done for the Institute. I understand that they are responsible for this volume.

Now, as to the question of the continuation of the work of the Question Box, that has also been a very excellent work, but it occurred to me to suggest, Mr. President, whether or not that had not better be left to the Governing Board. They know better than we do the present condition of our finances. Undoubtedly, that work, or a work of essentially the same character, should be carried on, but just how and under what circumstances, and whether or not we are in a position to begin it now or not, are questions that can be better answered, as it seems to me, by the Governing Board. Certainly I am not in a position to have an opinion on that subject.

MR. DONALD MCDONALD: Mr. President, in line with what Mr. Clark has said with regard to the Question Box, it seems to me that it must be two years ahead of the Revision Committee. In order to put the Revision Committee into shape where it will be the most valuable to us. I think that the matter should remain with the Governing Board, even if it results in the Question Box lying dormant for awhile. It will not do any harm if it results in that, because the Revision Committee cannot catch up with the present Question Box for some time to come. I think it should be left with the Governing Board, just as Mr. Clark says.

MR. DOHERTY: Mr. President, I know more, perhaps, about carrying on the work of the Question Box than a great many here, because that was in my hands entirely. When

the work was first started, it required a great effort and a very considerable expenditure to get the gas men of the country interested in the work. Various means were tried to arouse interest, but finally a system of advertising was used similar to the "follow up" system that is used by mercantile houses around the country. The result of it was that the number of contributors, and the number of men who became interested in the Question Box work, continually grew. I think the last Question Box had something like 570 contributors. The need for active work and active pushing of the Question Box was largely due to the fact that the scheme had made an unfavorable impression on a great many of the prominent gas men of the country, and consequently they did nothing to help it for some time. Gradually, however, when they became better acquainted with the plan, and saw what the work was, and what it was intended to do, and that it was run not particularly for the education of the best engineers in large plants, but was intended to bring up the education of the men located in the little gas works that did not have the benefit of association meetings and matters of that sort, then all that opposition disappeared, until today there is practically none that I know of. There are now a great many men interested in the work, and are willing to contribute without any expense at all the information which they possess that we want for this purpose. The work has grown steadily. As much as $3,500 has been expended on that publication in one year. It can be carried on very well now, however, by just availing ourselves of the men who are already contributing for an expense of from $600 to $1,000 a year. I believe that the work ought to be carried on, and ought to be kept up very much ahead of the work of the Revision Committee. The Revision Committee is not going, as I understand it, to publish a broad revision of all the work, but they are going to publish a revision of sections from time to time. It will not interfere with the work if the work of the Question Box is ten years ahead of them, because it will enable them to work on one section, and have that section right. I feel that the Revision Committee have broadened the work of the Question Box Committee, although with regard to the last publication of the Question Box no very serious

effort was made to arouse interest in the country, and it was not pushed as aggressively as previous publications had been. A few moments ago some of the members here were willing to sacrifice a large source of revenue, that coming from advertising, as a matter of dignity or sentiment. But that has not been allowed to stand in the way of the success of the Question Box. It is already doing good. I know of the good that the Question Box is doing because of numerous letters received from different men who have sent for a copy of the books, and I know it is valuable to the gas men of the country. Not necessarily to the men here today, but to the men at home. I believe the work ought to be continued, and it can be continued without the expenditure of any very great sum. I think it should be continued by the Institute, and if the Institute will not pay the necessary expense, I will contribute one thousand dollars to keep that publication up myself if anybody will undertake the publication of it. (Applause.)

THE PRESIDENT: That is the way to talk.

MR. NORRIS: Mr. President, if this resolution is going through, I think there should be some definite limit placed upon the expense to which the Institute is liable to be subjected. As I understood the motion, it was that the expense must be borne by the Institute. As has been stated, the expense has run as high as $3,500 a year, and I think it would be difficult for the Institute to expend even half of that, and if the expense is to be any such large sum, I do not think this motion should be allowed to pass without giving some care and thought to the subject. I would suggest, therefore, if the resolution is to be adopted, that it might go through in some such form as this: express the Institute's appreciation of the work and of its belief in the usefulness of the Question Box as a method of reaching gas men, and that it is the sense of the membership that the Institute ought to help support it financially, but the amount of that support should be left to the Governing Board.

THE PRESIDENT: That would be a recommendation to the Governing Board of the Question Box for favorable consideration.

MR. NORRIS: I would be in favor of giving it all the money it can properly use, and we can afford to spend, but I think that the amount of the expenditure should be under the control of the Governing Board.

MR. DOHERTY: My motion, Mr. President, was to leave the matter of the expenses in the hands of the Governing Board.

THE PRESIDENT: That is as I understood it.

MR. STONE: Mr. President, pardon me if I speak on the subject. We found in making up the paper that one of the serious objections to the Question Box, or rather one of the hardships which we had to overcome in revising the material, was the disjointed manner in which the information was given. In many instances there was no connection to it. There would be a whole lot of information on some one subject and nothing at all on others, so that in making up this publication I found it would be necessary to examine the records of the American Gas Light Association back for ten or twelve years, the Western for eight or ten years, and the Ohio from its beginning, and all textbooks and technical papers back for some years in order to get what little information is in here. Now that leads me to think that there is some sort of a solution to this question. I have thought since I have been sitting here listening to the discussion that it might be well to allow the Board of Revision to publish one section each year and let them ask the questions on which they desire information. Let the chairman of a section, for instance, if it is to be published next year, send out a printed list of questions for his section, asking for the information he needs to complete his work. And then, immediately after the answers come in, let him analyze the answers and select such of the material as is needed, and the section be published next year. By handling it in that way, it seems to me that the expense will not be as much as it appears to have been in the past, and in that way I think the work can be handled satisfactorily for we can get one section up to date, and we can get the information that more particularly pertains to the publication of that one section.

Mr. Doherty: It is not altogether an easy matter to determine what we would like to have in the Question Box. Mr. Stone suggests that one of the criticisms which has been made is that the information is not complete, and is disjointed. It should be remembered, however, that when you are asking for a voluntary contribution you must accept what is sent you. You cannot reject it, for if you do, and then ask for something more, you probably would get nothing. The work was very difficult to start with. As I said, however, a great deal of that early difficulty has been done away with. The work can be simplified from time to time. You can start it earlier, and you can get your replies earlier. Each year the work has been very much easier. We are now in a position to get better information and more diverse information. Now, it is only a matter of encouraging everybody to express their views.

My experience in connection with the Question Box work has led me to believe that Mr. Stone cannot send out from a given committee requests for answers to certain questions and get replies from them. Many may not have any information upon the particular subject regarding which he would inquire. I think particularly, Mr. Chairman, that the Question Box work ought to be carried on in advance of the Revision Committee, and I think that they can get all the information that will be needed by the regular mailing system. It makes no difference whether your list contains 180 questions or whether it contains 600, so far as the expense is concerned in sending it out. If necessary, the questions submitted by the committee on which they wanted information could be marked with a star, and everybody would understand that that was to be answered. Now, I have no interest in the matter except this: I believe that the Revision Committee, to effectually carry on their work and publish a complete handbook on gas manufacture, have got to know what the gas men of the country want. Whenever you pick up a handbook on a technical subject and look through it, no matter what it may be, it is apt to produce a very different impression upon you than when you are looking for information upon some particular matter. You look it through, and you are impressed with the great amount of information that it contains, but when you start to

look for something specific you are impressed with the fact that there is something left out. Now, if everybody is asked to answer questions on everything, you can limit the amount of information which must be gathered by original experiment to a very small amount, because you can make information which is known to one man common to all. I believe that the Question Box work ought to be carried on, and I believe that the general plan which was in vogue was the best that can be adopted. It can be improved from time to time, and can be made a great help to the work of the Revision Committee. When the Revision Committee wants information they can send their questions to the Question Box editor, and in that way he, gathering information for all, it is going right back into the hands of the Revision Committee.

THE PRESIDENT: Mr. Doherty, will you state your motion again, please?

MR. DOHERTY: My motion, Mr. President, was that the incoming President appoint an editor for the Question Box, and that the expense hereafter should be borne by the American Gas Institute, under the control of the Governing Board. My idea was that they would fix the amount that should be expended.

THE PRESIDENT: Gentlemen, you have heard the motion which was seconded. All in favor of the motion will signify by saying "Aye." Contrary minds, "No." It is carried.

The next thing on the program is the Question Box, by Mr. H. L. Doherty, of New York.

MR. DOHERTY: I resigned last March, Mr. President. I think we have just had a very good talk on the Question Box, so I do not think there is anything more that I can add.

MR. SHELTON: Mr. President, I think, as representing the Committee on Papers and Material for this meeting, that it was recognized that within the short time intervening between last March and this meeting we would be unable to secure a sufficient presentation of the Question Box, and it was, therefore, not expected that a report to this meeting would be made

covering the Question Box, and I think that reference to it on the program is an error.

THE PRESIDENT: Gentlemen, we are to have a paper from Mr. W. M. Welch, of Kansas, on behalf of the Natural Gas Association, on extinguishing a flame of 600 pounds pressure from a million foot hourly capacity natural gas well. Is Mr. Welch present?

MR. WELCH: Mr. President, I am ready to read my paper, except that I had hoped to have some lantern slides here to present in connection with the paper when it is read. Therefore, I would prefer to read it tomorrow if you are willing.

THE PRESIDENT: We will be glad to put this off until tomorrow in order that you may have your lantern slides here. "Delivery of Uniform Candle Power to the Consumer Through All Seasons of the Year," by Mr. W. H. Gartley, of Philadelphia. I will ask Mr. Gartley to come forward and read his paper. Gentlemen, please give attention to the reading of the paper.

DELIVERY OF UNIFORM CANDLE POWER TO THE CONSUMER THROUGH ALL SEASONS OF THE YEAR.

The purpose of this paper is to deal with the effect upon the candle power of the gas of those variable temperatures in the commercial holder and distribution mains, sure to be met with and beyond the control of the gas engineer.

Quoting from Mr. A. E. Forstall's paper on condensation:

"Condensation is perfect only when the gas leaves the apparatus carrying such an amount of the most valuable hydrocarbons originally present in it as it passes out of the retort as will just fall short of saturating it at the minimum of temperature and maximum of pressure to which it will be subjected during its journey to the burner."

Although this sentence, as written, refers to coal gas, it is equally true and more important for water gas, which usually contains a higher percentage of the most valuable hydrocarbon vapors that may be carried to the burner.

Continuing quotation from Mr. Forstall's paper:

"The attainment of this perfection of condensation is rendered difficult by the fact that the various hydrocarbons have a solvent action upon each other, which makes it almost impossible to condense out the vapor of any one of these, even though its boiling point be high and its tension low, without at the same time bringing down more or less of those vapors with low boiling points and high tensions that, if diffused in the gas, after the heavy vapors have been removed, would be retained under all conditions of temperature and pressure met with during distribution, while, on the other hand, the lighter vapors held up at low temperature some of the heavy vapors that but for this mutual action would be condensed out at comparatively high temperatures."

The solvent action that these hydrocarbons have upon each other, referred to by Mr. Forstall, will bear a little closer consideration.

When a gas, saturated with hydrocarbon vapors is cooled an infinitesimal fraction of one degree, it will be in equilibrium with its condensate and the proportion of the component vapors in the gas and in the liquid bear a fixed relation to each other. This is expressed in a law formulated by Mr. Henric Anderson, of Philadelphia, as follows:

"When a gas is in contact with a mixture of liquid hydrocarbons under condition of equilibrium, each of the components of the liquid makes its vapor tension valid in the gas in proportion to its molecular percentage in the liquid."

Let us suppose, for example, a gas at 50° F., standing in equilibrium over a condensate made up of equal parts by weight of Benzene and Toluene.

The weight of a molecule of Benzene, C_6H_6, is 78 and of Toluene, C_7H_8, is 92. The number of molecules of each in a mixture of equal parts by weight would be in proportion for Benzene $\frac{50}{78}$ and for Toluene $\frac{50}{92}$ or as 641 to 543 and the molecular percentage of Benzene would be $\frac{641}{641+543} = 54.1\%$, and molecular percentage of Toluene would be $\frac{543}{641+543} = 45.9\%$.

The vapor tension of the composite vapor in the gas would be:

		Vapor Tension at 50° F.
From Benzene	$.541 \times 45.2$ mm. $=$	24.543 mm.
" Toluene	$.459 \times 10.5$ " $=$	4.819 "
		29.272 mm.

And the percentage of vapor in the gas would be $\frac{29.272}{760}$ $= 3.85\%$, of which Benzene would be $\frac{24.453}{29.272} \times 3.85\% = 3.22\%$ and Toluene would be $\frac{4.819}{29.272} \times 3.85\% = .63\%$.

We see that a gas standing over equal parts by weight of Benzene and Toluene, with which it is in equilibrium, will contain 3.21% by volume of the vapor of Benzene and .63% by volume of the vapor of Toluene. The deduction follows that when a gas saturated at 50° F. and containing 3.22% by volume of Benzene and .63% by volume of Toluene is cooled very slightly, it will drop out Benzene and Toluene in equal proportions as to weight. The weight of equal volumes of vapors of Toluene to Benzene being as 1 to 1.18, there is left in the vapor in the gas an increased percentage of Benzene to Toluene; with such a vapor the condensate of equal parts is not in equilibrium and a re-arrangement results through which some of the Benzene vapors in the gas go to the condensate. This is what Mr. Forstall refers to as solvent action.

When a gas, saturated with hydrocarbon vapors, comes in contact with a condensate from which it is far removed from equilibrium, the re-arrangement to establish equilibrium becomes more violent, and we say that the gas has been shocked. This explains also why it is important to remove from contact with the gas in the process of condensation, the condensate at about the temperature at which it was deposited. To do this requires large volumes of cooling space, which cooling must be conducted in gradual steps.

While the proportion of high to low tension vapors in the gas is constantly increasing during the condensation process, bear in mind that because of the cooling the composite vapor tension is decreasing.

It also appears that we cannot expect theoretically an entire elimination of the tar vapors from the gas; at each step a portion is taken out, indeed, a large per cent., but even with a

perfect dephlegmation there would be a trace left to be carried to the burner.

In water gas practice, the problem of condensation reduces itself to the elimination from the gas of as much of the vapors of tar as possible, without leaving behind in the tar any of the high tension vapors that can be carried to the burner. To do this, the gas should be cooled as gradually as the condensing apparatus permits, and should pass into the purifiers at not less than 100° F., and through them without any loss in temperature. Under these conditions, the gas will reach the inlet of the commercial holder with only such changes in temperature throughout the year as the varying atmospheric temperatures between the purifier outlet and the commercial holder inlet may effect. During the process of condensation and purification, the temperatures maintained should be those best suited for the mechanical and chemical reactions, and should be unaffected by the varying atmospheric temperatures at different seasons of the year.

The gas arrives at the commercial holder saturated with composite vapor, some of which must be dropped on further cooling. Some will be dropped in the commercial holder and some in the mains.

Sample of oil taken January 25, 1906, from on top of water in the commercial holder tank:

Benzene	11.3%
Toluene	28.3%
Abv. Toluene	60.4%

Samples taken from street drips, March 14, 1906:

	Drip 2½ miles from works.	Drip 5 miles from works.
Benzene	12.2%	18.8%
Toluene	52.8%	54.0%
Abv. Toluene	35.0%	27.2%

This is from a mixture of 6 parts of water gas, made from Texas distillate, to 1 of coal gas.

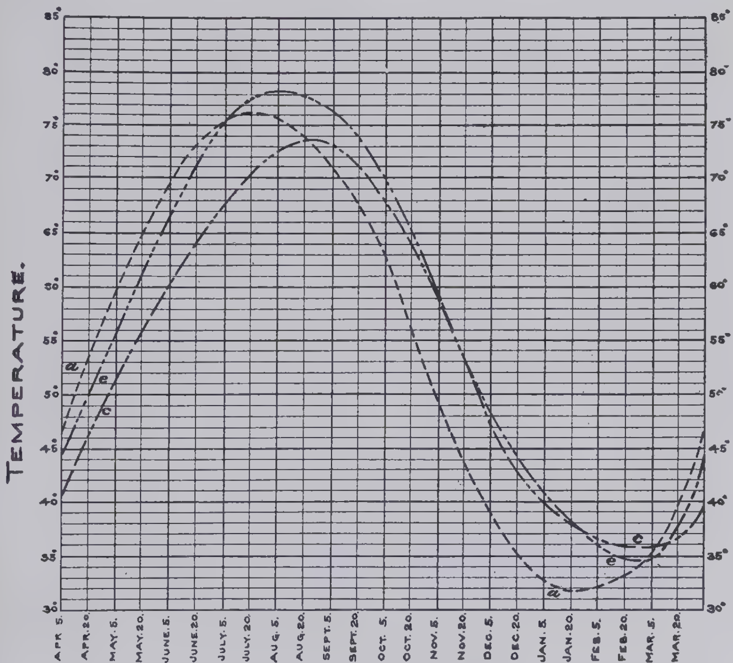
On plate 1 are shown the temperature curves of atmosphere and street main temperatures in 30″ main at the gas testing

PLATE I

CURVE. *a* MEAN ATMOSPHERIC TEMPERATURE 35 YEARS.

c TEMP. OF DISTRIBUTION MAINS 1 MILE FROM STATION A.

e " " GENERAL DISTRIBUTION MAINS.



THE UNITED GAS IMPROVEMENT CO.

PHILADELPHIA WORKS

SEPT. 26. 1906.

8-Q-76.

station located one mile from the works. While the temperature of the gas at the inlet to commercial holder varies from 90° in summer to 72° in winter, you will note that the temperature of the main at the testing station varies from 75° to 35°. What is the result of such a reduction in temperature upon gas containing approximately 3½% of condensible vapors of a composition as stated?

For a clearer understanding of the influences of cold weather on the gas in the commercial holder and mains, let us apply the principles of equilibrium of a saturated gas and its condensate to a dephlegmating column; that is, a condensing column, in which the gas flows upward against its condensation. As the gas rises from warm temperatures at the bottom to cooler temperatures at the top, the vapor in the gas in the upper and cooler part, through previous separation of condensation richer in low tension vapor, will be proportionately richer in high tension vapor and will shed condensation with a gradually increasing proportion of high tension constituents. This condensation, in dropping down the column and meeting gas shedding condensation less rich in high tension constituents, will, to establish equilibrium, give off some of its high tension constituents to the gas.

This is, theoretically at least, the ideal method of condensation; by having such a column with the base temperature so hot that only the least trace of high tension vapors can stay in the condensate, and the top at the minimum temperature to which the gas will be exposed in the mains, we would conserve to the gas the maximum of high tension vapors and have no condensation after the column.

On plate 2 is shown the percentage of loss of candle power by passing a sample of the gas from holder inlet through a cooling coil. The coil consisted of seven turns of ½" pipe, immersed in a water bath, the temperature of the bath and velocity of flow being so arranged that the gas arrives at the temperature desired at the point of exit. The inlet temperature was maintained at exactly 70°, care being observed that the sample did not fall below 70° before entering the coil. Tests were made by passing the gas downward and another series upward from—

PLATE II

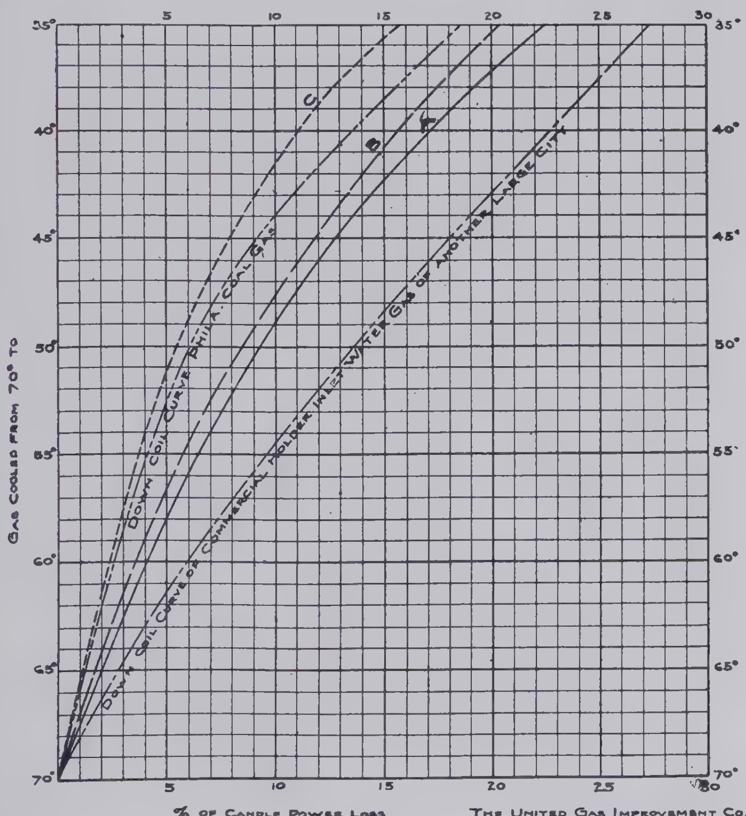
CURVES OF LOSS IN CANDLE POWER BY REDUCTION IN TEMPERATURE

CURVE A – DOWN COIL ————————————

CURVE B – UP COIL — — — — — —

CURVE C – PHILA. HOLDER & DISTRIBUTION MAINS AT TEST STATIONS. - - - - - - - -

A, B & C FROM MIXED GAS, 6 PARTS WATER GAS (TEXAS OIL DISTILLATE) TO 1 PART COAL GAS.



THE UNITED GAS IMPROVEMENT CO.
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8-6-74

70°	to	60°	F.
70°	to	50°	"
70°	to	45°	"
70°	to	40°	"
70°	to	35°	"

The failure of the two curves to coincide will be understood.

On this chart is also shown a curve, laid down from observation, of the loss in candle power between the works and testing station in Philadelphia for variations in temperature throughout the year. We do not lose as much candle power in practice as is shown by the coil. There appears to be in the holders and mains a better dephlegmation or slower cooling than in the coil.

At first blush it would appear that with the knowledge given on plate 2, as to loss of candle power for any given fall in temperature, as shown by the thermometer in the 30″ main at the testing station, we could calculate readily what should be the candle power of the gas at the commercial holder inlet to produce say 22.5 candle power at the testing station.

Our experience has shown that the problem is somewhat more complicated. A gas in its passage through the mains is affected in temperature at different points by local conditions. The deciding condition is the temperature of the ground at the varying depths of the main. The temperature at which the gas enters the main does not have any noticeable effect on the temperature of the gas in the main at even a short distance from the works. The total heat units given up by the gas are quickly dissipated through the large mains and surrounding ground, and the gas soon arrives at the temperature of the earth surrounding the mains and continues at such. In a long run the main varies in its depth below the surface. In the winter, where it approaches the surface, or for other reasons such as crossing under a bridge, there will be points where the gas is chilled below the temperature that would be shown by the thermometer in the main at the testing station. At such low temperature points there will be, of course, a final deposition of vapor, and after leaving these points, being again somewhat warmed, there will be a tendency towards

drying up of any condensate that may be encountered in the main, and when this is accomplished, subsequent gas will pass on unsaturated.

Our curve deals only with gas saturated at each temperature, consequently there is introduced a disturbing factor when we attempt to figure out what the candle power must be at the holder to yield a desired candle power at the testing station, the temperature in the main at the testing station being known.

Since the gas in warming from its minimum temperature cannot deposit condensation, it cannot lose in candle power and it therefore becomes necessary to determine its vapor dewpoint at testing station instead of its temperature.

Plate 3 shows a so called Hygrometer, designed for this purpose. It is made up of two concentric tubes, the concentric chamber being closed at the top, having an opening at the bottom and side. The inner test tube contains, to about one-third of its depth, some highly volatile liquid, such as Pentane, and is equipped with a glass dipping tube and hand pump for bubbling air through the Pentane, the resulting carburetted air passing out at the opening in the cork and conveyed beyond the danger point by a smaller rubber hose. The gas passes into the concentric chamber, between the inner and outer tube at A, and passes out at B, where it is allowed to escape or is burnt. By bubbling the air from the hand pump through the Pentane, the temperature of the air can be reduced and measured on the inserted thermometer, so that when it arrives at a point where there is condensation from the gas on the outer side of the inner tube, we can read from the thermometer the dewpoint of the gas, either for aqueous vapor or for hydrocarbon vapor. If a preliminary chamber, containing Calcium Chloride, is attached to the bottom of the hygrometer at A and the gas is first passed through this chamber, the dewpoint observed will be that of the hydrocarbon vapors. If this preliminary chamber, or a similar one, is attached, loosely filled with black rubber, such as fine rubber bands, the hydrocarbon vapors will be absorbed, and the observed dewpoint will be that for aqueous vapors.

Referring again to plate 5, curve f shows the saturation

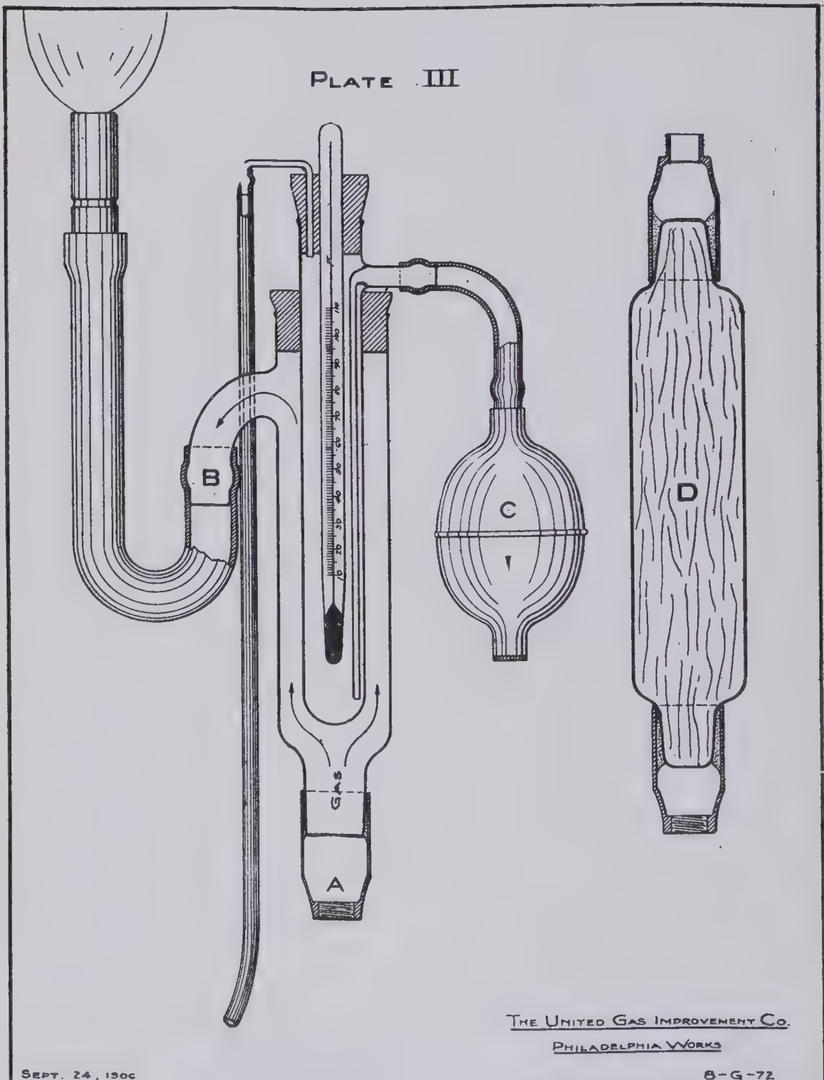
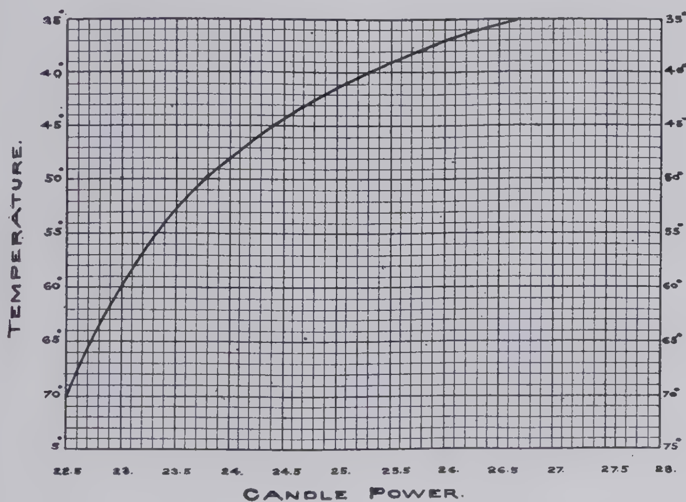


Plate III
B
C
D
Gas
A
The United Gas Improvement Co.
Philadelphia Works
Sept. 24, 1906
8-G-72

PLATE IV

INLET GAS CANDLE POWER REQUIRED TO MAINTAIN 22$\frac{5}{10}$ CANDLE POWER AT TEST STATION VS. TEMPERATURE OF HYDROCARBON VAPOR DEWPOINT AT TEST STATION.

NOTE:—
OBSERVE HYDROCARBON VAPOR DEWPOINT AT TEST STATION, USE AS ORDINATE, AND READ FROM CURVE NECESSARY CANDLE POWER REQUIRED AT COMMERCIAL HOLDER INLET TO YIELD 22.5 CANDLE POWER AT TEST STATION.



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9-G-61.

temperature for the gas at the testing stations throughout the year, and is given to show, in a general way, how it varies from the observed temperature. Curve e on plate 1 shows the temperature inside the smaller street main, the observations being taken at one point about 2½ miles and another point 4 miles from the works. It will be observed that they do not materially vary from those at the testing station and we may safely assume that the hygrometric readings at these points bear the same close relation to those at the testing station, so that by carrying in the winter a slight excess of candle power at the testing station, we may, and, by observation, we know that we are delivering the required candle power through the city mains.

Plate 6 shows the mean atmospheric, testing station dewpoint and testing station main temperatures in February and July of 1906.

In Philadelphia the candle power readers at the testing station determine the hydrocarbon vapor dewpoint of the gas in the main and report it to the works. By referring to the curve on plate 4, the Superintendent determines what must be the candle power at inlet to holder. This curve is laid out from data given by the curve on chart 2, which, as stated, has been drawn from our observations of loss in candle power between the works and testing station throughout the year,

We are required to maintain 22 candle power at the testing station. Allowing ½ to ¾ candle power extra for any future reduction in dewpoint between the testing station and the consumer, we are convinced by hygrometer and photometer observations in other parts of the city that we have delivered 22 candle power to the remotest points. With this method in use, we find that no importance need be attached to the loss of candle power from friction in the mains and other vague causes.

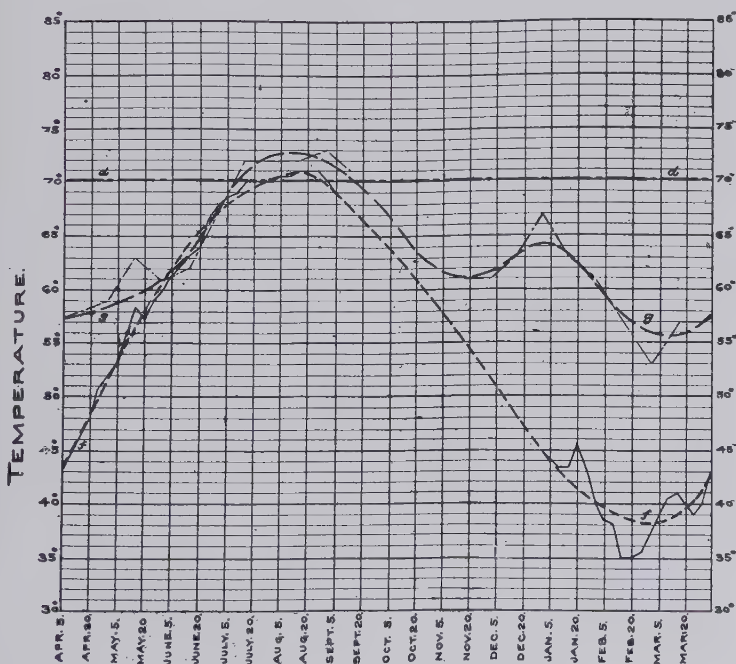
Anticipating one point in the discussion of this paper, I attach plate 5, showing general smoothed out curves of dewpoints of the gas at outlet of holder and at the testing station main. You will readily conceive the fluctuation in the dewpoint from hour to hour at holder outlet, influenced, as it is sure to be, by weather changes and speed of warm gas through holder.

PLATE V

CURVE *d* TEMPERATURE OF PHOTOMETER BATH

f HYGROMETER READING AT TEST STATION

g HOLDER OUTLET



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PHILADELPHIA WORKS.

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8-G-75.

The curves on plate 5, as well as those on plate 1, must be understood to be simply curves showing generally the temperatures that will be encountered by the gas. They are not to be considered as of actual daily use.

Curve g will necessarily vary for each works. Experience shows that hourly changes of dewpoints at holder outlet are less than might be expected. At Station "A," using two 3,000 M. holders, sending out about 16,000 M. mixed gas per diem, the dewpoint varied between 59° and 56°, while the thermometer fell from 42° to 20° F. Even here the gas has lost approximately .8 of 1% of its candle power in cooling from 59° to 56°, and the superintendent should be able to keep this fact in mind so clearly that there will be no alteration of operating conditions to get a gas that will "hold up" better. We must realize that whatever the change in the dewpoint at holder outlet, if that dewpoint is above that at the point in the distribution system corresponding to the testing station, there need be no anxiety felt, because the candle power at the testing station will not be changed

If, however, the attention is chiefly directed to the holder inlet candle power, which may always be led to the photometer saturated at some standard temperature, selected here at 70°, by passing through an up coil, immersed in bath at 70°, we have a solid basis to work on unchanged throughout the year.

I have intended in this paper to lay down the general principles of a method for securing not only uniform candle power to the same consumer from hour to hour, but a method that will give gas varying only slightly in candle power over the entire distribution system.

In order to show the uniform candle power delivered to the consumer by the application of this method in Philadelphia, I give the average daily candle power during a period of low dewpoints, that is from March 16th to April 1st. Each day shows the average of the twenty four hourly observations by the candle power readers at the testing station. The candle power desired to be carried was 22.75.

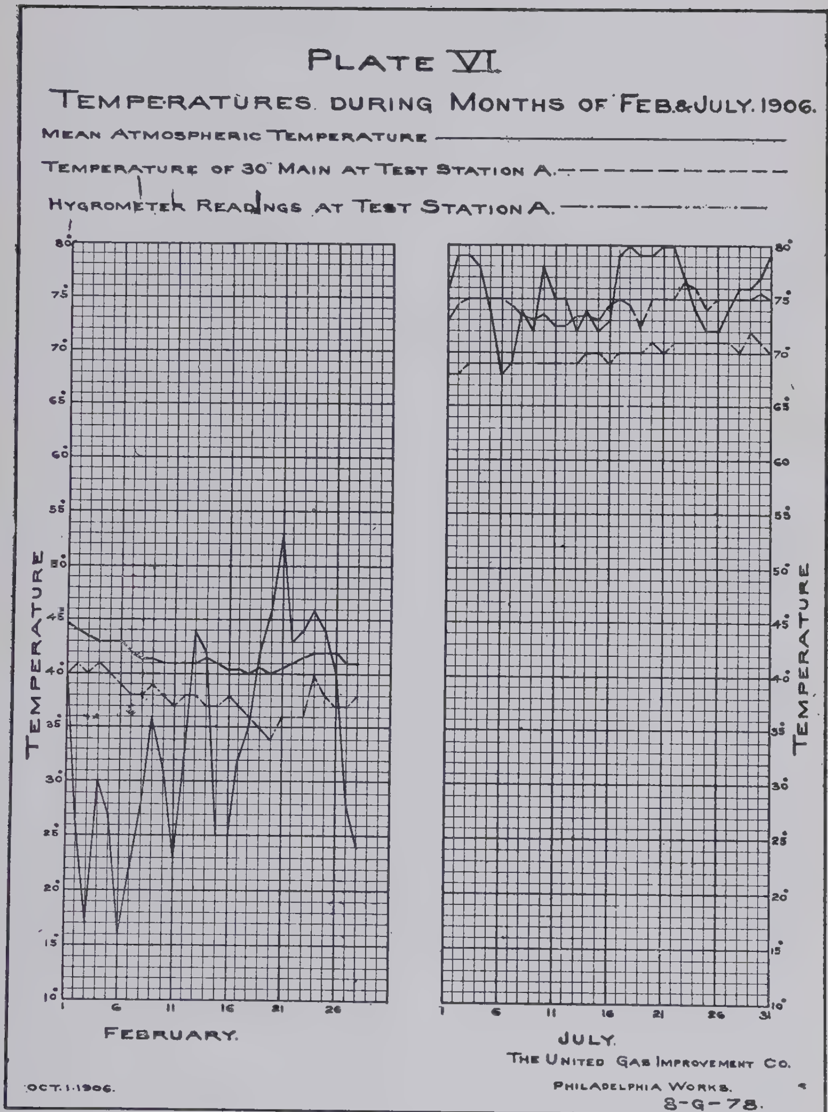


PLATE VI.
TEMPERATURES DURING MONTHS OF FEB.&JULY. 1906.
MEAN ATMOSPHERIC TEMPERATURE
TEMPERATURE OF 30" MAIN AT TEST STATION A.
HYGROMETER READINGS AT TEST STATION A.
TEMPERATURE
FEBRUARY.
JULY.
THE UNITED GAS IMPROVEMENT CO.
PHILADELPHIA WORKS.
OCT. 1. 1906.
8-G-78.

	"A"	"B"
March 16th,	22.69	22.96
" 17th,	22.52	22.63
" 18th,	22.44	22.56
" 19th,	22.54	22.83
" 20th,	22.90	22.86
" 21st,	22.67	22.73
" 22nd,	22.74	22.71
" 23rd,	22.60	22.43
" 24th,	22.78	22.49
" 25th,	23.04	22.79
" 26th,	22.75	22.76
" 27th,	22.82	22.63
" 28th,	22.52	22.35
" 29th,	22.88	22.35
" 30th,	22.92	22.48
" 31st,	22.66	22.44

It has been found that the lowest dewpoint temperature will be coincident with thawing weather, following severe frost, when the cold water soaks deeper in the ground.

We did not arrive at this seemingly simple method, without meeting many contradictory and disappointing results that cannot be touched on without using too much of your valuable time, but I hope that you will permit me to speak a little further on the subject of photometry and the precautions necessary in getting reliable comparative results in two photometers situated one mile apart.

We read candle power hourly, both at the works and testing stations, the candle power readers having no other duties. They work in three shifts of eight hours, and at both the works and testing stations report to a chief photometrist, who, with the Superintendents, report to the Engineer of Works. In the works' photometer room, the works' Superintendent has no authority and has no control over candle power readers' work, except to request more frequent readings if desired.

Each works makes coal gas and water gas, and for photometric samples a separate coil immersed in a 70° bath is provided for each gas; that is, one for each of the coal gas,

water gas, mixed gas at holder inlet, and commercial gas. Also a separate photometer meter is provided for each kind, through which the sample is kept constantly flowing, to be switched on to the photometer burner as desired. Hourly readings are taken of the candle power of each gas, and more frequently if desired by the Superintendent. At each works two bar photometers are provided and are in constant use in adjoining rooms, thus giving a check upon each other if there is reason to doubt the accuracy of either from some undetected maladjustment.

At the testing station the temperature of the gas must not be allowed to fall below main temperature outside.

For such frequent readings and particularly in a climate like that along the 42nd parallel of latitude, we found it necessary to abandon candles promptly. Our experience with candles gives good ground for the statement that, under the conditions enumerated, standard sperm candles are impracticable as a source of light.

The representative of the municipality, Dr. N. W. Thomas, after carefully weighing the merits and demerits of the different lamps, decided upon adopting the Pentane lamp. After six years' experience with this lamp, having 12 in constant use, I am inclined to urge this Institute to take the necessary action to make such further investigation of its peculiarities as will be necessary to adopt it as a standard of light for the gas companies of this country, or reject it in favor of something better.

While the Carcel, Hefner and Harcourt 10 candle Pentane lamps are all in use, our investigation discloses the fact that but one of these, the Harcourt 10 candle Pentane lamp, has been adopted as a standard by legislation. This lamp is the standard for the Gas Referees of London, the Examiner for the London County Council, the National British Physical Laboratory, and is also used as a standard in the Electrical Testing Laboratory in New York. In this country it has been the subject of investigation, and some of the results have been presented to the Gas Associations. They indicate the need of making further investigation as to certain peculiarities.

We are dilatory in taking action on standardizing photometrical methods in this country. The urgency of action

arises from the tendency of municipalities and state authorities to frame laws regarding inspection of our product. In the case of the District of Columbia, Congress legislated that the gas must be equivalent to 25 candle power, measured on a Bunsen Photometer. This was the same photometer specified in the Gas Works Clauses, Act of Parliament of 1871, which goes with considerable detail into the method and apparatus required. In later legislation by Parliament, providing for the appointment of Referees for certain companies, much of this method of testing described in the Act of 1871, was repealed and left to the Referees for those companies with which they were officially connected, but Parliament in all these Acts specified that for common illuminating gas, the candle power shall be determined by burning through a Sugg's London Argand Burner. The Gas Referees of London, having to deal with gas of 12 to 16 candle power, have made seemingly wide departures in the method of photometry, and the gas companies of this country have not followed them. If, therefore, we do not get together and formulate specifications based on proven scientific methods, we will have less cause to complain if we are served with something in the way of legislation that proves difficult to digest. As an illustration, this year, in one of the large cities, a University Professor was engaged by a newspaper to make observations of the candle power furnished by the gas companies; he used a photometer that recommended itself largely because it could be carried in an ordinary suit case. I will say that no observations are entirely accurate when the gas saturated with hydrocarbon vapor, or nearly so, is passed through rubber connection.

DISCUSSION.

The President: Gentlemen, you have heard the reading of this most valuable paper, and I hope it will be given a very thorough discussion. Mr. Gartley, will you please have a seat on the platform? Mr. Forstall, will you have anything to say on the subject?

Mr. Walton Forstall: Mr. President, I regret it very

much, but my line of work has been for many years in connection with the distribution of gas exclusively.

The President: Mr. Walton Clark, will you not have something to say on this subject?

Mr. Walton Clark: Mr. Gartley has said about all that I can say. I will say, however, that it has been a very important matter with us at home in Philadelphia to maintain our standard of candle power with the least use of oil. We are very rigidly held to 22 candle power at a point a mile from the works. We have not felt, however, that we were entirely meeting the expectations of the people of Philadelphia simply supplying 22 candle power gas a mile from the works; and we have made every effort by experiment and investigation in the hope of being able to find a method by which we could maintain that candle power to the consumer without having it much above 22 at the testing station. Mr. Gartley set up photometers in many parts of this city, and has given a great deal of study to the question. How well he has succeeded the paper shows. He and Mr. Bond, and the other men who worked with them, have worked out their method. There may be other methods of doing it that are equally successful, but there is no method that is more successful, I think, because as he has shown in his paper, that, carrying a candle power of approximately 22¾ at the testing station, a mile from the works, he is able to deliver 22 candle power to his consumers generally. That shows, I think, that the method is eminently successful.

The President: Mr. McDonald, will you discuss this?

Mr. D. McDonald, Louisville: Mr. President, I have nothing to say. I think it is all right because Mr. Gartley says so.

Mr. Nettleton: May I say a word before Mr. Gartley replies? I confess that I am astonished at the results claimed. I am free to say, however, that I do not see exactly the difference between his method and the usual practice. As I understand Mr. Gartley, he is using an oil that has the reputation cf producing a gas, the candle power, of which

falls off badly in extremely cold weather. If Mr. Gartley will explain what he does to make his candle power hold up, I will be greatly obliged.

Mr. Gartley: I do not wish to be understood as saying that there will be no falling off in candle power when the gas is cooled. One of the purposes of my paper is to show how much the falling off in candle power will be. If you will refer to Plate 4, you will find there a curve that gives the loss in candle power that is found in a gas made from Texas oil, between the limits of 70 degrees and 35 degrees. For instance, if it has been found that the gas will drop in the mains to 40 degrees in temperature, this curve shows that we must put into our commercial holder a gas of 25.3 candle power, the gas being cooled at the inlet to the works' photometer to 70 degrees to yield 22.5 candle power at 40 degrees. I do not mean that the gas must show forty degrees on a thermometer inserted in the main at the testing station; I mean that the gas shall have been cooled as low as 40 degrees somewhere between the works and the testing station, and this determination is made not by a thermometer, but by the hygrometer described in the paper. If it has been cooled at some intermediate point and is then increased in temperature again before arriving at the testing station, it would be a gas unsaturated with hydrocarbon vapors, and as curve 4 deals only with gases saturated, and as the gas after being cooled to 40 degrees cannot increase in candle power between that point and the testing station, the hygrometer will show the temperature which must be applied on curve 4 to tell us what candle power we must put into the commercial holder. Do not understand me as saying that the gas to the consumer will fall 2.8 candles under these conditions, because such is not the case. The difference is due to the fact that on a bar photometer (which is the only accurate means of determining candle power) the gas is passed through a wet meter, while the consumers' gas is passed through a dry meter. If a gas that has been cooled to 40 degrees passes into a photometer meter, the temperature of which is 70 degrees, the gas will absorb water vapor in the meter until it becomes saturated with water vapor at 70 degrees. At 40 degrees the gas contained .83 of 1% of water vapor. At 70 degrees it will have

picked up 1.6% of water vapor additional. The gas as metered on the photometer will have 97.57% of illuminating gas and 2.43% of water vapor, while the gas that goes to the consumer will have 99.17% of illuminating gas and .83 of 1% of water vapor, and the consumer will, therefore, get a higher candle power than that shown on the bar photometer. In this particular the bar photometer, as at present, introduces an error, and is an example of what I hope a committee appointed to investigate the method of candle power determinations will consider. A solution would be the use of a dry meter on the bar photometer, at least where it is to be used in making determinations at different points in the distributing system.

Mr. Gardiner: Mr. President, I have been extremely interested in Mr. Gartley's able paper, and in the scientific methods which he has brought to bear in the solution of his problem. I certainly hope that the work will be prosecuted along the lines he suggests. It occurs to me, however, that it might not be expedient to have this question of candle power spread upon the records without making a statement of what I take to be a fact in regard to it, and that is, that important as it is today, I understand it is becoming less and less so. In reality, most of the gas from many gas companies is today sold for its calorific value. I simply make that statement so that it will be borne in mind in conjunction with this subject of candle power.

Mr. K. M. Mitchell: I think the point that Mr. Gartley has made about the establishment of a standard of taking candle power is of the utmost importance. I think it should be taken notice of, and that there should be some recommendation made to the Institute about the matter, so that it can take it up, and not allow it to go along, simply appearing upon the record, without calling attention to the fact that some method of standardizing candle power should be maintained or recommended by the Gas Institute.

What Mr. Gardiner has said about taking the value of gas by heat units is in order, too.

Mr. Earnshaw: Mr. Gartley's paper is of peculiar interest to me because I had the privilege of assisting in the earlier

development of the system of candle power control which he has so ably described, and I can testify that his present success is only due to careful scientific method and the most painstaking and comprehensive experimental work. Mr. Gartley's treatment of the subject presents the question of candle power regulation in an entirely new light, and many a worried manager will thank him for showing the way to overcome a serious problem.

There are a few points brought out by Mr. Gartley to which I wish to call particular attention. Mr. Gartley states: "When a gas, saturated with hydrocarbon vapors, comes in contact with a condensate from which it is far removed from equilibrium, the re-arrangement to establish equilibrium becomes more violent, and we say that the gas has been shocked." This statement is theoretically true, but is of practical effect only when the surface of condensate exposed is very large in proportion to the volume of gas. A gas saturated with hydrocarbon vapor, and standing over a condensate with which it is not in equilibrium, can only suffer change in its vapor content by the slow process of diffusion, and the establishing of a condition of equilibrium with the condensate involves an important time factor.

In practice the effect of "shock" is achieved in a somewhat different way. When a gas saturated with a composite hydrocarbon vapor is exposed to a sudden and extensive lowering of temperature, the condensate forms as a mist, and is in contact with every particle of gas and uncondensed vapor. The normal condensate due to the lowered temperature contains a large proportion of low temperature vapors, but due to the principle stated it is not in equilibrium with the vapors remaining uncondensed in the gas. An immediate readjustment takes place, whereby a large proportion of the valuable high tension vapors go to the condensate and are deposited as tar and lost. If, on the other hand, the cooling is gradual, and time allowed for the tar mist to settle out as a liquid, the injurious readjustment occurs only in a lessened degree, and an increased quantity of high tension vapors are carried forward to the final stages of condensation.

It follows, therefore, as Mr. Gartley says, that it is

important to remove from contact with the gas in the process of condensation the condensate at about the temperature at which it was deposited. To this fact is due the great value of the relief holder in water gas condensing, and the known good effect of air condensers of large volume for coal gas.

To summarize the points brought out by Mr. Gartley, let us suppose that a manager wishes to avail himself of this system of candle power regulation. The important points to be observed are:

Uniformity of generator house practice.

Careful regulation of temperature conditions in the condensing and purifying operations.

Reliable observation of the candle power of the gas at inlet to commercial holder, the gas always reaching the photometer at a fixed standard temperature.

Observation of the hydrocarbon dewpoint at a point in the distribution system sufficiently remote from the works.

Determination of the candle power required at holder inlet to deliver desired candle power at the temperature indicated by dewpoint.

Mr. Gartley's description of the methods used in Philadelphia cover everything required, but it is important to observe that gas made from different characters of oil will behave differently when cooled, and the loss in candle power for a given face in temperature will vary.

It follows that it is desirable and even necessary to secure an oil supply of uniform character, and if necessity compels the use of different qualities an effort should be made to avoid mixing and provide separate tanks for each kind of oil. By the aid of a cooling coil the candle power loss at lowered temperature can be determined for the grade of oil in use, and a curve constructed that will enable the works' superintendent to know what candle power he must make to maintain the desired candle power in the distribution system.

The President: Gentlemen, is there any further discussion on this paper?

Mr. Egner: Mr. President, I was very much interested

in Mr. Gartley's paper, and we all are interested in photometry, in making it as definite as possible, or so as to make the readings as definite as possible. My observation has been that the old methods, where the candle power has been taken by different men, even at the same time and with the same gas, the results are not the same, hence cannot be accurate. In that connection I want to say, Mr. President, that I have been struck with the simplicity of the selenium photometer. And I have wondered why it was not adopted more generally. I think it has been recommended before but it has not received the attention that it deserves. Some matter about it has been published in the American Gas Journal, but it has been strange to me that it has not been more fully investigated and used. The selenium photometer is very simple, and it is scientifically accurate. No matter what the difference of eyesight in men may be who read it, they are bound to arrive at the same result. I thought I would mention the matter at this meeting of the Institute as perhaps it may be taken up by some of the gentlemen present. The selenium photometer depends largely on the property of selenium to conduct electricity more easily in light than in darkness, and anybody, almost at sight, can read the candle power of the gas, and there can be no mistake made at all. It can always be read like print. I am not prepared to give a close description on this at this time, and I do not know as it would be pertinent to the paper if I did, but I would like you all to try to look up the selenium photometer. One of its strongest points is its accuracy and simplicity. Besides that, it does away with all the objections which we have found to the jet, and to the bar photometer, because it is bound to be scientifically accurate and every one that takes an observation with it must arrive at the same result. If any number of men take an observation of the same gas with a selenium photometer their results will be the same. There will be no difference. And that is the main difficulty which it has sought to overcome in connection with the bar photometer, where a difference in the wick of the candles used would often seriously affect the results obtained. This cannot happen with the selenium photometer. I am very much

surprised that manufacturers of gas measuring apparatus have not taken it up and brought it out because the whole question of accuracy in photometers could be solved by using an apparatus as described by Mr. H. Raupp, of Mayence, Germany, at the meeting of one of their Associations during the present year, and illustrated in the American Gas Light Journal of August 27th last.

THE PRESIDENT: Gentlemen, is there any further discussion on this matter?

MR. EGNER: I would just like to say this in addition, Mr. President. This paper of Mr. Gartley's shows great patience and research, and great care in its preparation. A great deal of time must have been spent upon it. Many papers have been read upon this subject in the past, and much discussion has been had, but when we have such a substance that can be applied in photometry, and is so scientifically accurate as selenium appears to be, it is too bad it is not better known. Perhaps no one in this room has seen the selenium photometer. I hope some one will take the matter up and bring it to the attention of the Institute at some future date.

Mr. Gartley's paper brought this subject to my mind. It is a property of selenium to conduct electricity in light better than in darkness, and because of that attribute it is also proposed to use it for the automatic lighting and extinguishing of lamps, especially public street lamps. And I think we are much indebted to Mr. Raupp, Superintendent of the City Gas Works of Mayence, Germany, to have again brought the subject prominently to the attention of the gas industry.

I am not well enough versed to give you a complete description of the photometer, but I know that all of this can be and has been practically demonstrated. It is certainly worth while investigating, gentlemen.

MR. GARDINER: Mr. President, I would like to move that the incoming President be requested to appoint a committee to investigate as to methods of taking candle power gas.

Motion seconded.

THE PRESIDENT: Gentlemen, you hear the motion as

made by Mr. Gardiner. His motion is that a committee be appointed by the incoming President to investigate methods of taking the candle power of gas. All in favor of the motion will say "Aye." Contrary minds, "No." The "Ayes" have it, and the motion is carried.

Mr. Gartley, we thank you very much, sir, for your valuable paper.

SECRETARY DUNBAR: I am requested to announce that the Illinois Gas Association will have a meeting immediately upon adjournment of the Institute in Club Room No. 4.

I will also state that the system of registering attendance is a card system, which is in charge of two persons at the entrance in the anteroom. Those of you who have not registered will please do so as soon as possible. To the 881 who have registered on the membership list and its supplement that has been distributed, there are some additions to be made. Some applications have come in since these were printed. These persons, when they register their attendance, will please give their names, occupation and their residence. The applications which came in yesterday and today we have a record of downstairs, so that the persons who have given their applications in today and yesterday need give themselves no further concern about them.

THE PRESIDENT: Gentlemen, we are to have a paper on the effects of high pressure upon illuminating gas, by Mr. Edward C. Jones, of San Francisco. Mr. Jones, I understand, is not present, and the paper will be read by the Secretary.

THE EFFECTS OF HIGH PRESSURE UPON ILLUMINATING GAS.

In order to determine the results of compression upon the chemical and physical properties of illuminating gas, the writer used a portable gas compressor operated by a gasoline engine. This first stage compressor effects compression up to 100 lbs., and delivers the gas into a steel tank 5 ft. long, 12 inches diameter, furnished with a gauge, and an outlet leading

into a second stage compressor capable of raising the pressure to 300 lbs., and in its turn delivering the gas into another horizontal tank 6 ft. long and 10 inches diameter, also supplied with a gauge.

The second stage compressor was especially designed for this work, and consists of two tandem differential cylinders, the largest of which is operated by gas pressure at 100 lbs. from the first stage compression tank, and raises the pressure by operating the piston in the smaller cylinder. The apparatus might be termed a gas run.

From the second stage compression tank, the gas was admitted to an upright galvanized iron house boiler 5 ft. long by 11 inches in diameter, fitted with a gauge and blow off valve. This boiler communicates directly with a bar photometer.

The gas used for these experiments was what is known as crude oil water gas at 21.6 candle power. This gas is made from 14° Baumé, California crude petroleum, without the use of solid carbon in any form. It is a well fixed gas, and is used for all purposes throughout the Pacific Coast, and with the exception that it has a higher percentage of illuminants, it resembles coal gas so closely that it might also be called an artificial coal gas. Its specific gravity was .413, and it contained 626 British Thermal Units per cubic foot.

The experiments were made with unpurified gas, which analyzed as follows:

Illuminants	7.00
Marsh Gas	29.7
Hydrogen	50.0
Carbon Monoxide	5.2
Carbonic Acid	3.0
Oxygen	Trace
Nitrogen	5.1
	100.00

A successive series of compressions was made with an increase of 30 lbs. at each compression. Fresh samples of gas were used in every case; that is, gas that had been once compressed was not used again in any succeeding compression. After each compression an analysis and a photometer test were made, and the results tabulated as follows:

The Effects of High Pressure Upon Illuminating Gas.

Table A.

Lbs.	C_nH_{2n}	CH_4	H_2	CO	CO_2	O_2	N_2	Sp. Gr.	B. T. U.	C. P.	
0	7.0	29.7	50.0	5.2	3 0	Tr.	5.1	.413	626	21.6	H_2S 200 Grns.
30	6.8	29.8	50.1	5.4	2.8	Tr.	5.1	.411	625	20.0	
60	6.8	29.6	50.2	5.5	3.1	0.1	4.7	.412	624	17.0	
90	6.8	29.6	50.3	5.5	3.1	Tr.	4.7	.411	624	16.0	
120	6.7	29 5	49.2	5.6	3.2	0.1	5.7	.422	618	15.0	
150	6.7	28.8	51.3	5.5	3.3	0.1	4.3	.407	617	14.0	
180	6.5	29.0	51.0	5.5	3.0	Tr.	5.0	.407	615	11.1	
210	6.0	29 0	51.0	5.7	3.2	0.1	5.0	.408	607	9.6	
240	6.3	29.0	51.0	5.4	3.2	0.1	5.0	.408	611	10.8	
270	6 0	29.1	51.6	5 5	3.2	0.1	4.5	.403	610	6.2	
300	5.7	30.0	51.4	5.6	3.0	0.1	4.2	.399	614	5.5	H_2S O "

April 12, 1905.

The most remarkable effects of compression are the continuous reduction of the candle power and the elimination of naphthalene and sulphuretted hydrogen. From a candle power of 21.6, the gas dropped to 17 candles at 60 lbs., to 11.1 candles at 180 lbs., and to 5.5 candles at 300 lbs. The crude gas contained 200 grains of sulphuretted hydrogen per 100 cu. ft., while the 300-lb. gas contained no sulphuretted hydrogen.

The appearance of the flame of the compressed gas is very deceptive. It looks fair, and to the naked eye its color is unchanged. When compared with standard candles, its richness is seen to have gone, and when observed through the spectroscope, the yellow portion of the spectrum has narrowed and the blue and green increased.

The next point of interest was whether the liquid compression product could be reintroduced into the compressed gas upon releasing the pressure. The 300 lbs. gas was brought into contact with the compression liquid, and the candle power rose from 5.5 to 29.3 candle power. To enrich this compressed gas, it is not necessary to scrub it with compression liquor. It is required only that the gas should pass over the surface of the liquor.

The most important point of all, when the condensed illuminants were restored to the gas, it was discovered that the sulphuretted hydrogen did not again appear in the gas. The explanation of this, I believe, is that the sulphuretted hydrogen on leaving the gas combines chemically with some of the hydrocarbons to form an organic sulphide or mercaptan.

In support of this, the compression liquid gives no test for sulphuretted hydrogen with lead acetate, and if the liquid is distilled, the hydrogen sulphide does not appear until near the last fraction where all the sulphuretted hydrogen and naphthalene appear. This fraction gives an immediate test for sulphur with lead acetate, showing that the heat has dissociated the sulphuretted hydrogen from some other compounds. Moreover, if sulphuretted hydrogen made in the laboratory be dissolved in the compression liquid, that liquid will then give the lead test for sulphur, and heating will drive off all the sulphuretted hydrogen so dissolved before the first fraction has come off. Such liquor will also foul pure gas.

The Effects of High Pressure Upon Illuminating Gas.

Table B.

Lbs.	C_nH_{2n}	CH_4	H_2	CO	CO_2	O_2	N_2	Sp. Gr.	B. T. U.	C. P.	
0	8.4	27.5	50.3	5 0	4 0	0.2	4 6	.425	653	20.9	H_2S 260 Grns.
30	8.3	24.8	54.1	5.0	4.0	0 2	3 6	.402	635	20.8	
60	6.0	23.6	55.5	6 8	3.8	0.2	4.1	.393	587	17.6	
90	6.2	26.2	53.3	5.0	3.6	0.2	5.5	.401	606	11.5	
120	6.4	24.0	55.6	5.0	3 6	0.2	5.2	.390	594	11.1	H_2S 70 Grns.
150	6.2	21.2	61.5	5.0	3.6	0.3	2.2	.348	580	9.7	
180	5.8	24.4	57.3	4.8	3.2	0.2	4.3	.371	591	8.6	
210	5.7	22.9	60.2	5.0	3.1	0.2	2.9	.349	584	7.2	
240	5.4	23.0	59 4	5.0	3.1	0.3	3.8	.357	576	6.5	
270	5 6	22.2	60.2	5.2	3.0	0.2	3.6	.352	575	5.8	
300	6.2	22.8	58.0	4.8	3.2	0.2	4.8	.371	585	4.7	H_2S O "

September 8, 1906.

A later series of tests shown in the second table confirm the results of the first series.

The crude gas contained 260 grains of sulphuretted hydrogen, and when compressed to 120 lbs. the gas only contained 70 grains, and the gas at 300 lbs. pressure contained no sulphuretted hydrogen.

The greatest loss of candle power was between 60 and 90 lbs., while in the previous series it was between 30 and 60 lbs. This may be explained by the fact that the candle power of the first gas was higher than the second and had not the stability, its additional candle power being derived from illuminants more easily removed by compression.

The writer is familiar with the many experiments heretofore made to determine the effects of compression upon the candle power of illuminating gas, and has had experience in the compression of large quantities or gas commercially to supply the various high pressure systems in California. The writer has also become aware of the great difficulty of ascertaining the actual damage done to the gas by compression on account of the avidity, one might say thirst, with which the gas reunites with its condensed hydrocarbons.

In the foregoing series of experiments great care was taken to use fresh samples of gas, and to remove every trace of condensed liquor before each experiment.

In many high pressure systems, where no condensed liquor is drawn off, no loss in candle power is observed. It has, therefore, been taken for granted that no reduction in candle power occurred.

The writer uses in connection with all high pressure systems under his care a simple re-enriching tank, through which all the compressed gas finally passes before going into the main pipes. This is called an "auto-enricher" on account of its simplicity and self-operation. It consists of a compression tank placed horizontally, with an inlet at the top at one end, and an outlet at the other top at the end. This compression tank is placed at the outlet of any other storage compression tanks there may be in the system, and all gas, as well as all compression liquor, must pass through this tank. No compression liquor is drawn away, and the mere contact of the

compressed gas with the liquor satisfies the lack of hydrocarbons and restores the gas to its normal candle power. This is proven in practice in many large systems every day, and one of its strange features is that there is no over or under enrichment of the gas.

To sum up the results of these experiments, we find that the compression of gas removes sulphuretted hydrogen and naphthalene, and if the compression is carried as high as 300 lbs. per square inch, purification in gas works may be dispensed with.

The purification of gas by compression is ideal, as it is continuous and cleanly, requires no purifying material, nor expensive and cumbersome purifiers.

The compressed gas, besides being freed from sulphur impurities, contains no naphthalene, and while this is recognized as a valuable illuminant, its value is more than offset by the troubles it causes.

The gas is not damaged in illuminating value if the condensed hydrocarbons are kept in contact with it, and to demonstrate the actual effects of high compression upon the gas, it became necessary to exert great care that the results should not be misleading because of the ease with which the gas takes up condensed hydrocarbons and resumes its normal candle power.

DISCUSSION.

The President: Gentlemen, you have listened to this paper. It certainly seems to be a valuable one, and one that gives us much good information that is of value. I would be glad if there would be a free discussion of this paper.

A Member: Mr. President, I just want to call attention to one point. I do not quite understand the paper, but as it appears I do not see very much use in taking the sulphuretted hydrogen out if it is going to be put back in another form. In other words, as I understand the paper, it simply takes the sulphur out in one form and puts it back in another.

Mr. Norris: I understood that it came out in the condenser and did not remain in the gas.

Secretary Dunbar: The gas upon being released took up no sulphuretted hydrogen, and Mr. Jones' explanation was that it formed an organic sulphide.

Mr. Gardiner: In that connection I would like to say that under some statutes or municipal ordinances the presence of sulphuretted hydrogen in itself is forbidden whereas a certain definite amount of sulphur is allowed. Therefore, if a certain gas is low in sulphuretted hydrogen and the sulphuretted hydrogen is transposed a direct advantage may thereby be obtained.

In connection with this paper I would like very much to ask as to the relative cost of purification under this system, including general fixed charges.

Mr. A. S. Miller: Mr. Chairman, I think, as was just intimated, that there is an intent upon the part of the author to state that it goes back into the gas in the form of vapor and carries the sulphur with it. Also, I should think in ordinary practice we would find it very difficult to carry back to the gas its proper proportion of hydrocarbons. If we were to compress a lot of gas for delivery a long distance away, some of it might get its proportion of carbons and some might not. I am sorry that the author is not here, as I think he has left the question of sulphur somewhat obscure.

Mr. Walton Clark: It hardly seems possible that Mr. Jones can mean that there goes back into the gas for every 260 grains per hundred feet of gas taken out 260 grains of sulphuretted hydrogen, which is almost all sulphur. That is gas which could be distributed but it could not be burned with any comfort.

Mr. A. S. Miller: It is a most interesting proposition that we can take sulphur out of gas by compression and keep it out.

A Member: In the paragraph next to the last in the paper, Mr. President, I think that the author throws some light upon that, and rather intimates that it does not go back. He says that the compressed gas, besides being freed from

sulphur impurities, contains no naphthalene. He says so emphatically.

Mr. Shelton: Mr. President, I am sorry that Mr. Jones is not here to explain more clearly some of the apparent discrepancies which have been referred to. There are some statements here which are surprising. I cannot, either, entirely account for them myself. Mr. Jones has opened up to us rather a new point of view, a new line of thought, and a suggestion for original work. I might suggest that this has developed in direct response to the invitation of the Institute to all of the associations to be represented here and present papers. I think, aside from the technical value of Mr. Jones' paper, that it has been an exceedingly kind thing for the Pacific Association to proffer, for the benefit of this Institute, the first word on the unusual subject in question.

As to this question which has been raised as to whether the sulphur goes back into the gas, I think he has said that it did not go back into the gas. He also says in his paper on page 87 —as to the point to which Mr. Miller referred—there was no over or under enrichment of the gas, but that it seemed to pick up the proper amount upon passing over condensation.

I do not propose, Mr. Chairman, or profess to be able to offer any explanation of these things. We can only regret that Mr. Jones is not here. He has certainly opened up a new line of thought for us. I think that the Institute ought to do its full duty in the expression of its appreciation of the receipt of the paper.

Mr. Bond: Mr. President, in regard to the enrichment, I would like to call attention to the statement that Mr. Jones makes in the third paragraph on page 84 of his paper. He says that "the 300 lbs. gas was brought into contact with the compression liquid, and the candle power raised to 29.3." He states before, as I take it, that he started with a candle power of 21.6, and then it seems to go up to 29.3 from compression. That is according to this paper which is printed. Now in that connection I would like to ask another question, and that is just how much gas he passed through his photometer before he went from the determination of one candle power to another.

It seems to me that the amount that is given there cannot be very much. I notice, too, that this method is not regular. I would call attention to that table on page 83. You will notice in one or two places the gas seems to rebound. At 180 lbs. he gives the candle power at 11.1, and then it goes down to 9.6, and then it goes back to 10.8. You will notice also that it takes 180 pounds in the first instance to bring it down to 11 candles, while in the third instance it was down to nearly 90 pounds pressure.

THE PRESIDENT: That probably was some mistake, because in the other table he shows a continuous drop.

MR. BOND: The question arose in my mind as to what extent these candle powers going down and showing a loss are exposed to partial restoration. They get down finally to a very small amount in the gas.

THE PRESIDENT: Is there any further discussion, gentlemen? Mr. Shelton, you have had some experience with compressed gas.

MR. SHELTON: Unfortunately, Mr. President, my experience has not been in connection with photometrical operations or with that kind of oil gas process.

MR. NORRIS: I am a little surprised at the small loss at thirty pounds pressure. There are quite a number of men here who have compressed pretty high in connection with high pressure distributing systems, and I would like to hear from some of them whether their experience bears out these small losses.

MR. EGNER: Mr. President, I have had a little experience with compressed gas, and the results were laid before one of the gas associations, I think, in '91. It was with oil gas or Pintsch gas. I do not know whether that applies, but in a gas of that kind, which was compressed up to 220 pounds, the loss was a little bit inside of two and one-half candles. The measurements were made by Mr. Chollar. He made them very carefully, and I believe we were going to the Western Association meeting at the time. To the best of my recollection, there was a loss of two and one-half candles in the candle

power between when taken before compression and after compression.

The President: Any further remarks?

Mr. Morton: One of the points that seems to be brought out by these tables is that it seems to be impossible to tell anything about the candle power from any but a very refined chemical analysis of the gas. In one case we have 6% of illuminants and 17.6 candles, while in another we have 6.2, a higher percentage of illuminants, and the candle power is only 9.7. Some few days ago I was engaged in a discussion as to whether candle power of gas could be determined from a chemical analysis, and this seems to bear out the fact that until we have a complete analysis of the illuminants, the chemical analysis would be very misleading.

The President: Any one else anything to say on this subject? If not, the thanks of the Association will be extended to Mr. Jones for what I consider a very valuable paper.

Mr. Egner: Mr. President, I think this is a very important matter, and it might be well to refer it to a committee to investigate a little further. I think it would be a good idea for the Association to do that. That is the very thing that the American Gas Institute was organized for—to investigate such things. It could be done without any special expense. I hope it will be referred to somebody to investigate further and report at our next meeting. That, I think, would be the right thing to do.

Mr. Shelton: Mr. Jones' paper is in the line of co-operation with other associations, if I may refer back to that. I think it will be one of the objects of the new Directors to go forward in this practical work with other associations, especially in the line of that such as this paper, which is of so much interest. I simply hope that the new Board of Directors will consider it part of their duty to help to develop all of these problems.

Another point that I wanted to make was that I would like to see this Institute request our Secretary to transmit to the

Pacific Coast Association a sense of our appreciation for the paper tendered by Mr. Jones on this subject in behalf of that Association, and, moreover, that instructions be given to the Secretary that he write a similar letter to each one of the other associations who have been represented here by gentlemen who have read papers, such as the Natural Gas Association, the Commercial Gas Association, and the Illuminating Engineers. It seems to me that we are indebted to the writer of such a paper as this, and we are indebted to those other associations for manifesting such a spirit of willingness to appear as they have and give us the benefit of these very valuable ideas. I think that the more of this kind of thing that we can have the better it will be for all concerned. In passing this vote of thanks, I think that we ought to follow it up with such a letter from the Secretary.

Motion seconded.

THE PRESIDENT: Gentlemen, you have heard the motion of Mr. Shelton that we express our appreciation for the papers from our sister associations. All in favor of the motion will say "Aye." Contrary minds, "No." The "Ayes" have it, and the motion is carried.

A motion to adjourn will be in order.

MR. SHELTON: Mr. President, I simply wish to say, before we adjourn, in regard to the matter of the dinner, that it has all been arranged. There have been about 125 seats taken so far. Arrangements can be made for more if they care to participate.

Convention adjourned to 10 A. M., Thursday, October 18th.

SECOND DAY—MORNING SESSION.

Convention called to order at 10:28 a. m., President B. W. Perkins in the chair.

THE PRESIDENT: Gentlemen, the Secretary has some letters and telegrams of regret, of which he will read a few.

SECRETARY DUNBAR: I have received the following letters and telegrams, some of which I will read:

New York, October 10, 1906.

James W. Dunbar, Esq., Secretary,
New Albany, Ind.

My Dear Mr. Dunbar:

I am just in receipt of the formal invitation to attend the first annual meeting of the American Gas Institute to be held at Chicago, October 17th to 19th inclusive.

If my plans should change so that I could even be present on the first day, I shall certainly take advantage of the opportunity and be with you.

Wishing you every success, I am,

Sincerely yours,
Alex. C. Humphreys.

Saginaw, Mich., Oct. 13, 1906.

James W. Dunbar, Acting Secretary,
American Gas Institute,
Auditorium Hotel, Chicago, Ill.

Dear Sir:

I beg to acknowledge receipt of your invitation to attend the first annual meeting of the American Gas Institute and regret exceedingly that other engagements prevent my presence.

With best wishes for a successful meeting, I remain,

Yours very truly,
S. E. Wolff, *General Manager.*

220 Broadway, October 13, 1906.

The American Gas Institute,
Care Mr. Paul Doty, St. Paul Gas Light Co.,
St. Paul, Minn.

Gentlemen:

On behalf of the Illuminating Engineering Society, permit me to extend to the American Gas Institute on the occasion of your Inaugural Meeting in Chicago on October 18th, my best wishes for the success of your organization.

The underlying idea of the Illuminating Engineering Society is co-operation in all that makes for the good of the science and art of illuminating engineering.

With this idea in mind, our Society will be glad to get into close touch with the American Gas Institute and to co-operate with your members in all questions relating to the field of work to which the Illuminating Engineering Society confines itself. Very truly yours,

L. B. MARKS, *President.*

MIDDLETOWN, OHIO, Oct. 17th.

James W. Dunbar, Secretary, American Gas Institute,
Auditorium Hotel, Chicago.

Regret exceedingly cannot be present at the first meeting of the Institute. G. N. CLAPP.

SAN FRANCISCO, CAL., Oct. 17th, 1906.

American Gas Institute,
Auditorium Hotel.

Pacific Coast Gas Association extends congratulations and best wishes for future prosperity. Incidentally, Pacific Coast operates today largest gas engine in the world, 5333 horse power, with illuminating gas 642 British thermal units.

JOHN A. BRITTON, *Secretary.*

Also a letter of regret from E. G. Love, of the Department of Water Supply, Gas and Electricity, 122 Bowery, New York.

Oct. 10th, 1906.

Mr. James W. Dunbar, Acting Secretary:

MY DEAR SIR—Please accept my thanks for the invitation to attend the first annual meeting of the American Gas Institute. I regret exceedingly that I shall not be able to be present, but I beg to offer my hearty congratulations to the members of the Institute, and to wish them a most enjoyable and profitable time. Very truly yours,

E. G. LOVE.

A letter of regret from D. W. Low, of Alliance, Ohio.

ALLIANCE, OHIO, Oct. 15, 1906.

Mr. James W. Dunbar, Acting Secretary, American Gas Institute,

Auditorium Hotel, Chicago.

DEAR SIR—Enclosed find my report as Editor of Forms and Records. I am sorry I was unable to get it in to you sooner. I myself am sorry to say I will be tied up and will be unable to attend, as much as I would like to.

Hoping the first meeting will be a grand success, I remain,

Very truly yours,

D. W. LOW, *Editor.*

Also:

WASHINGTON, D. C., October 11, 1906.

American Gas Institute, B. W. Perkins, Presiding Officer,

Auditorium Hotel, Chicago, Ill.

DEAR SIR—Mr. John R. McLean desired me to say that business in Washington compels him to regret his inability to attend the first annual meeting of the American Gas Institute, to be held at the Auditorium Hotel, Chicago, on October 17th, 18th and 19th, 1906.

Very truly yours,

H. B. DOWNS.

LONDON, Oct. 18, '06.

Gas Institute,

Auditorium, Chicago.

Cordial greetings to new Gas Institute; much regret absence at birth.

GLASGOW.

THE PRESIDENT: The next matter upon the program will be the report of the Editor of "Bureau of Records and Forms."

Will Mr. Forstall read this report of Mr. Low's?

REPORT OF THE BUREAU OF RECORDS AND FORMS.

Members of American Gas Institute:

GENTLEMEN—As Editor of "Bureau of Records and Forms"

of the Ohio Gas Light Association, I beg to submit the following closing report:

I do not think the result obtained from the collection such as has been compiled by the Editors of this Bureau is bringing out the results which were expected when the Bureau was inaugurated, which was to help get a uniform system of blanks and Records by compiling the Records and Forms of each company in a form to be accessible to all members of the Association. I do not think the result has been as we expected, for although any of us can go over this collection, and derive a great amount of information from same, the trouble is the majority of us will take certain portions of a blank, or certain blanks of a system, and inaugurate it into our own system, but we are not willing to adopt any complete system, the forms of which are shown in the collection. How many have actually adopted the American Gas Light System, and why not?

If the American Gas Institute intends to take up any of this kind of work, I would make the following suggestion: That a committee be appointed to collect the complete systems of all the companies in this Institute, and compile from same a complete Standard System of Blanks and Forms to conform to the systems used by the majority of the members of this Institute. These can be made flexible enough to apply to the small as well as the large companies.

If these were published in pamphlet form and distributed, free of cost, as the Electric Light Association did, I believe it would do a great deal toward inaugurating a Standard System of Accounts, and give the man who wishes to open up a new set of books, a system which, when he takes off his balance, will give him some idea where he is. I am afraid, by sending a collection of blanks such as is now in my possession, would simply confuse him, and he does what the rest of us do, takes a little of each.

Thanking the members of the Ohio and other Associations who will help me compile our present collection, I remain,

Respectfully yours,

D. W. Low, *Editor.*

THE PRESIDENT: What is to be done with this report?

MR. KENAN: I move that it be received and filed.

THE PRESIDENT: Are there any remarks, gentlemen, upon this motion? All in favor of the motion of Mr. Kenan will signify by saying "Aye." Contrary minds, "No." The motion is carried.

Is Mr. Lansingh in the room? If so, is he prepared to read his paper?

MR. VAN RENSSELAER LANSINGH: Mr. President and Gentlemen: I have been asked to give this paper on behalf of the Illuminating Engineering Society, and while I am here representing them to a certain extent, I should like to say that the Society is not responsible at all for the sentiments expressed.

THE STANDARDIZATION OF INCANDESCENT GAS MANTLES.

When electricity first began to be a competitor of gas in the field of illumination, there was great fear among the gas interests that gas was to be supplanted by electricity, with the result that gas securities at once fell off in value, and it was some time before they recovered. It is not difficult to see why this panic arose. We can take as an average condition that gas at that time sold for $1.25 per thousand cubic feet (which is probably low) and that it gave approximately 16 C. P. per 5 cubic feet. This made the cost to the consumer per hour ⅝ of a cent for 16 C. P. If we assume that the electric lamp of that period consumed 4 watts per candle and that the cost of current was 20c per KW. hour, the cost to the consumer was 1¼ cents per hour for a 16 C. P. lamp or twice the price of gas. When all the conveniences of electricity were considered as compared with gas, it was seen at once that if improvements in the efficiency of lamps and a reduction of electric rates were possible, electricity would shortly very largely displace the open flame gas burner. This reduction in the rates of electric current and improvements in lamp filaments did occur, but at the same time a new powerful factor came to the aid of the gas industry, namely the Welsbach or mantle burner. At the

time, many gas companies feared that the introduction of this burner, consuming from 3½ to 4 cubic feet of gas per hour and giving in the neighborhood of 60 C. P., would mean a serious reduction in their revenues, and bitterly opposed its introduction. As a matter of fact, the mantle burner proved the salvation of the gas industry, as far as lighting was concerned, as the ordinary open flame gas could never hope to compete with electricity, with the lowering of rates and the introduction of more efficient lamps. The introduction, then, of the mantle burner proved to be a most powerful factor in the gas field and opened up new sources of income to the gas company and enabled it not only to meet electric competition, but in many cases to overcome it.

Up to perhaps a year ago, the situation had resolved itself as follows:—It might be taken on an average that gas was being sold for $1.00 per thousand cubic feet, and that the standard mantle burner, consuming from 3½ to 4 cubic feet, (3½ under laboratory condition, 4 under actual service) was giving a candle power of 60 candles. Electricity on the other hand was averaging perhaps 8c per KW. hour, (in many cases more and in many cases less) and the standard lamp throughout the country was 3½ watts per candle. In the large cities the customers were supplied with 3.1 watt lamps, but in the smaller places it was not unusual to find 4 watt lamps. Under these circumstances electricity for the same candle power was about 4½ times as expensive as gas.

Despite this overwhelming advantage for the gas industry, electricity, owing to its numerous advantages, has continued to grow, perhaps even more rapidly than gas, and in many cases at the expense of gas. It is not necessary here to enumerate these advantages in detail since they are probably fully as well known to the reader as to the writer.

Attention is called, however, to one or two important advantages of electricity which are often overlooked by the gas man, and which the gas engineer could do well to copy as far as possible. One of these is the ability to subdivide the light into any convenient size unit, varying all the way from powerful lamps of 100 candle power to small miniature lamps of one candle power or less.

Second—The ability to place these different size units in just the places where they are most needed and not attempt to illuminate a room by flooding all parts with light.

Third—The ability to equip the lamp with glassware which would either direct the rays of light in ways wanted, such as opal, prismatic, etc., or else give diffusion with comparatively small losses by absorption.

During the past year the situation from the electric standpoint has materially altered; there has been, in many cases, a reduction of rates, often of a more sweeping nature than corresponding reductions in gas, but the principal change has been in the introduction of new lamps of higher efficiencies. The first lamp of this nature to appear on the market was the GEM or High Efficiency type, consuming 2½ watts per horizontal candle power. This was followed by the Tantalum lamp consuming 2 watts per candle power and the electric industry is looking forward to the introduction of a new type of lamp, the Tungsten, which is promised shortly for the market at 1¼ watts per candle power. Other types of lamps such as the Osram, Osmium, Zirconium, Kuzel, etc., give promise of even higher efficiencies and it is confidently expected by the electric trade that within two or three years, there will be lamps on the market with an efficiency of perhaps ½ watt per candle or $\frac{1}{7}$ of the present 3½ watt standard. Granting, however, that for some time to come, the 1¼ watt lamp will be as high an efficiency as will be attained in commercial practice, we see that the electric man will be able to reduce his current consumption from 3½ to 1¼ watts per candle or a reduction of nearly ⅔ of the present cost. We therefore see that with the introduction of a lamp of this type, gas will be placed in the same position, perhaps not quite as good, as it was when we had only the old type of burner and the old 4 watt incandescent lamp. The cost of electric lighting then will not be greater than 1½ times that of gas and with a possible reduction to equal or even lower cost.

This is the situation to be faced, perhaps not to-day but very shortly. Even to-day with lamps of the Tantalum type taking 2 watts per candle, we find that electricity has a greater advantage over gas than formerly, as the cost is reduced to

nearly one-half of what it was. Thus if electric lighting has been able to grow at its former cost, it bids fair to grow even more rapidly under these conditions.

This then is the situation as it must be looked at and the question arises, how are we going to meet these conditions? In some cases we find that there has been a union between the gas and electric interests and that gas is pushed largely for cooking and electricity for lighting, but in the great majority of cases the gas and electric companies are separate and each is competing for all the trade it can possibly get. It is therefore necessary to analyze the situation carefully and see what the gas men can do to meet this threatening advance on the part of electricity.

It does not seem at the present that any great advance can be hoped for in increased efficiency of the present mantle burners for ordinary use. Something has been accomplished along this line through pressure burners, but generally this means a burner of such high intensity and high candle power that it is necessary to largely offset this added efficiency by the use of dense diffusing globe, so that little or nothing is gained. Moreover, the use of such burners is necessarily limited. It seems, therefore, that the best way to meet this threatening competition is by the best use of the present materials available.

Up to this time the gas man has given little or no attention to the correct placing and distributing of lights or to their equipment with the best glassware for the purpose in hand. In other words, the term "illuminating engineering" is almost unknown to the gas man, but that the gas industry is awakening to the necessity of more light on the subject is evidenced by the great increase in the demand for such information, and the fact that the Illuminating Engineering Society, but recently formed, numbers among its members those representing the largest gas interests of the country. In the transactions of this society the gas man finds the most authoritative data on the correct use of light, and the interest in this subject is one of the growing signs that the gas man will successfully meet electric competition.

One of the latest weapons placed in the hands of the gas

engineer is the inverted burner, where the natural distribution of light for ordinary illumination is far superior to the standard upright type. As far as distribution is concerned, it is possible with the inverted burner to generally obtain with ordinary glassware, as good if not better distribution than with the upright burner equipped with the best forms of redirecting and diffusing glassware. There are, of course, many disadvantages today with the inverted burner, chief of which must be reckoned the discoloration of fixtures, and it would seem that the gas engineer has a fruitful field in getting fixture houses to design a line of fixtures which are especially suitable for the inverted type. Even the question of finish is important, as the ordinary brush brass or polished brass fixtures tarnish very quickly with the heat. If, on the other hand, finishes such as verde antique or other dark finishes were used on both burner and fixture, the discoloration would show very much less. Of course, in many cases such finishes would not be suitable, but where they can be used it will do away largely with this serious objection. The attempt to adopt the inverted burner to the present type of fixture is generally unsatisfactory, but it should be an easy matter to design fixtures which will be suitable for the inverted type, so that it will be available in many places where not suitable at present.

One trouble with the inverted burner on the ordinary fixture today is that it concentrates too much light directly underneath, as the fixture is generally hung rather low. If the fixture was properly designed so that it could be placed close to the ceiling and the light governed by some form of distance lighter, such as the pneumatic and electric lighters which are now on the market, extremely good results could be obtained for lighting different classes of rooms. Further, if inverted burners in small sizes should be designed so that two or three units would only consume the same amount of gas as the present unit, we could obtain, when properly placed, a far more uniform or economical method of lighting. Such units could be placed closer to the ceiling than the larger ones, where the concentration of heat is an important matter. In other words, it would be possible by the burner companies constructing small burners, either of the upright or inverted

type, which can probably be made as efficient as the larger standard sizes, to meet one of the advantages which the electric man has today, namely, the ability of placing smaller units in positions where the illumination is desired.

Another way, where it is desired to use the upright form of burner, is to make a more careful study of the best forms of burners and glassware such as was given in the paper by the writer before the Western Gas Association in May, 1906. The ordinary opal "Q" globe, which has had such a phenomenal run, has been shown to be inefficient and should be replaced by better types. This paper does not admit of a fuller discussion as to how to improve the illumination by the best means available, but as this matter has been covered more or less fully in different technical papers, the writer would refer to the same.

There is one question, however, which has been given altogether too little consideration, namely, the question of supplying the customer not only with the best types of burners, glassware, etc., properly placed, but also with the very best mantles possible. It is not uncommon today to find some of the largest gas companies selling, and in many cases recommending a mantle which retails for from 5 to 10 cents, evidently failing to realize that it is impossible to give the customer the best satisfaction from such a mantle. Most of the electric companies have long ago graduated from such elementary ideas. We find today the large progressive electric companies going so far as to supply their customers, free of charge, with the best lamps obtainable and selected carefully for the voltage at the customer's place of business or residence, and also maintaining expensive organizations to keep these lamps in the best possible condition. By this means many of the complaints which formerly troubled the electric companies have been done away with, and they have been in better shape to meet the keen gas competition than would otherwise have been possible. When such a company buys its lamps, it buys them on a set of rigid specifications. Thus the lamp company furnishing the lamps must guarantee the initial candle power of the lamp; must guarantee that it shall not vary more than one or two volts either side of the rated voltage of the lamp;

must guarantee that its life will be so many hundred hours before the candle power has decreased to 80 per cent. of its initial candle power; must guarantee that all lamps be free from any mechanical imperfections, as well as fulfilling other requirements, and the question naturally arises: should it not be the policy of the up-to-date gas company to follow along the same lines? Why should not such a company buy its mantles on a set of rigid specifications, with a guarantee from the company from whom it purchases its mantles, that all mantles so purchased should live up to these specifications and with a penalty attached for any which fall below the standard? If this were done, it would probably do more to make satisfied gas customers than anything else which is at present available.

In order to find out whether there was any material difference between a cheap mantle and a high grade mantle, the writer has had a series of tests made at the Electrical Testing Laboratories of New York, on 40 mantles, 10 being of the highest grade obtainable, 10 of a medium grade, 10 of a still cheaper grade and finally 10 of a very cheap grade.

These four mantles are designated in the following tests as Nos. 1, 2, 3 and 4. No. 1 is an asbestos tied cap mantle supported by a ring and side rod, covered with a magnesia tube, selling to the trade for 20 cents. No. 2 is an asbestos tied, single side-rod supported mantle, the cap form of which wholesales for 13⅓ cents. This one was selected as it is often used with a center support. The price of the No. 2 is given in the cap form as the other three are of that type and this gives a better insight into the relative values entering into the mantles themselves. No. 3 is an asbestos tied, double rod supported cap mantle wholesaling at 8⅔ cents. No. 4 is an asbestos tied, doubled rod supported cap mantle wholesaling for 6⅔ cents. The 40 lamps were all burned on gas obtained directly from the mains of the New York Gas Company, New York City at pressures varying from 1.4 to 2.0 inches of water. The lamps were mounted on two pipes which were drilled and tapped to receive the nipples. These pipes were fastened rigidly to the floor and wall of a large basement room, nearby machinery producing a slight vibration at certain periods of the day. The lamps were mounted 10 inches apart, 20 upon

one pipe and 20 upon the other, being in rotation, No. 1, 2, 3, 4. No. 1, 2, 3, 4, etc.

It had been intended to photometer the lamps at intervals throughout the tests while in position upon these racks. As no pressure regulators were available, results obtained would have been affected by pressure variations in the mains. Therefore it was found simplest to remove the galleries to a nearby photometer room and there carry out the photometric tests. This was done, in every case the lamp being supplied with gas at a pressure of one and one-half inches of water. Of course such removal of mantles and galleries is decidedly objectionable and the value of these tests is not so much from the standpoint of absolute values, as it is to point the way for a more systematic and rigid investigation. However, as all mantles were tested alike, we are able to draw at least comparative results. Photometric tests were made at the start, at 96 hours, 194 hours and 555 hours. The 194 hour measurements are not comparable with the others inasmuch as the lamps were not removed from the rack and therefore there was a difference due to variation in pressure. These readings are therefore omitted in the report.

Among many of the mantles, minute breaks were observed during the first hour of burning, in some cases immediately after the mantles were burned off. The rather rapid increase in the number of such breaks made it apparent early in the test that the comparison of values would have to be based upon breakages more largely than upon candle power deterioration. In this case, time did not permit of the complete test upon any mantles which might be substituted for those which were broken among the first group placed upon test, consequently it was decided to run all mantles for as many hours as possible and note results. The breakage of ten chimneys at 364 hours however, (this breakage occurring when the gas was turned off the lamps) necessitated the removal from test of a corresponding number of mantles, no replacement chimneys being at hand. Those which were in the the worst condition were accordingly removed irrespective of the brand. At this time also the 5 other mantles which were unfit for further service

were removed from test. All other lamps burned for at least 555 hours.

It will be seen from the above description that these tests are not at all satisfactory from the standpoint of deterioration. They do show, however, a great deal relative to the mechanical strength of the mantles. Thus at the end of 555 hours, there were two mantles out of ten of the No. 1 and two mantles out of ten of the No. 2 which were in perfect condition, while none of numbers 3 and 4 were in good condition.

The detailed results of how the different mantles failed are not given here, inasmuch as this paper is meant to be suggestive rather than a complete study of the situation and only the general results are stated.

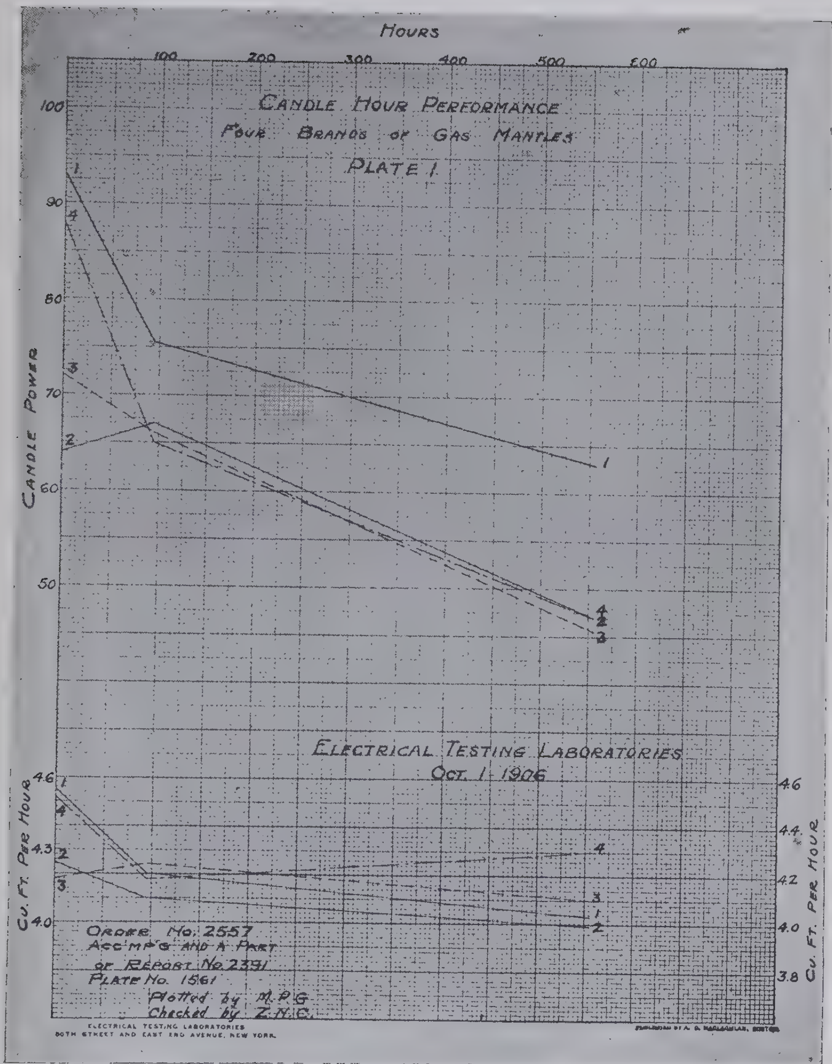
The following table shows the deterioration of the different types of mantles, the values representing the mean of the different mantles tested:

No.	Initial			96 Hours			555 Hours		
	C. P.	Cu.Ft.	C. P. per Cu. Ft.	C. P.	Cu.Ft	C. P. per Cu. Ft.	C. P.	Cu Ft.	C.P. per Cu. Ft.
1	93.0	4.55	20.5	75.5	4.2	18.0	63.0	4.07	15.6
2	64.4	4.25	15.4	67.0	4.10	16.4	47.2	4.0	11.9
3	72.2	4.18	17.4	66.3	4.26	15.6	45.5	4.1	11.3
4	88.0	4.52	19.5	54.6	4.18	15.5	47.0	4.3	10.9

These results are shown graphically on Plate 1.

Regarding the test on type 1, it should be noticed that the initial candle power falls off very rapidly during the first 100 hours, after which the deterioration is very much more gradual. The figures given are the mean of the six mantles which lasted throughout the test of 555 hours. On examining the ten mantles which lasted for 96 hours, we find that there is even a slightly greater drop during this time, so that this test shows rather conclusively that there is a decided tendency to fall off rapidly in candle power during the first 100 hours of life.

Type 2 shows that there is a slight increase in the candle power up to 96 hours. Only 5 mantles were included in these figures. In the original report, if we examine the complete test for ten mantles, we find that instead of a slight increase


Hours
100 200 300 400 500 600
Candle Hour Performance
Four Brands of Gas Mantles
Plate 1
Candle Power
100 90 80 70 60 50
1 4 3 2
Electrical Testing Laboratories
Oct. 1, 1906
Cu. Ft. Per Hour
4.6 4.3 4.0
4.6 4.4 4.2 4.0 3.8
Order No. 2557
Acc'mp'g and a Part
of Report No. 2391
Plate No. 1561
Plotted by M.P.G.
Checked by Z.N.C.
Electrical Testing Laboratories
80th Street and East End Avenue, New York.

at the end of 96 hours there is a decrease, so that in all probability a complete series of tests would show that the deterioration of this mantle was practically uniform, the same as is shown by No. 3.

No. 4 exhibits the same characteristics as No. 1, namely, a very rapid falling off in initial candle power and a more gradual decrease afterward. The rapid decrease in No. 4, however, is greater than in No. 1.

Plate 2 shows the characteristics of these four mantles with reference to their efficiency or the candle power per cubic foot of gas at different periods of their lives. This plate shows, as do the other tests, that mantle No. 1 is of much higher efficiency than the others throughout its entire life, and that No. 4, starting off with a high initial candle power, falls below the others after less than 100 hours burning. No. 2, although starting lower in candle power than any of the other mantles, is superior, with the exception of No. 1, throughout most of its life. Plate 2 gives perhaps as good an idea as is possible to obtain, graphically, of the relative values of these mantles, and shows that their values are, roughly speaking, in accordance with their costs. It is to be noted that there is, on the whole, comparatively little difference between No. 2 and No. 3, as far as the light-giving quality of the mantles is concerned. A breakage test, however, would show that No. 2 is superior to either No. 3 or No. 4, and No. 3 is better than No. 4. We thus see that the value of a mantle depends, not only on its candle-power hour performance, but also on its ability to withstand the usage which it is ordinarily subjected to.

It will be noticed that No. 1 deteriorated in candle power per cubic feet of gas in the 555 hours of test about 24% and Nos. 2 and 3 about the same, showing that these three mantles deteriorated about equally. No. 4, however, representing the cheapest mantle tested, showed a deterioration of no less than 46%. The net low efficiency throughout the life of the No. 4 mantle is largely explained by the fact that the skirts of these mantles at the cap wore off at the bottom until no longer overlapping the cap. In some part, the wearing away of the skirt of the mantle may be explained by the fact that after these mantles were burned off, in most cases they were no

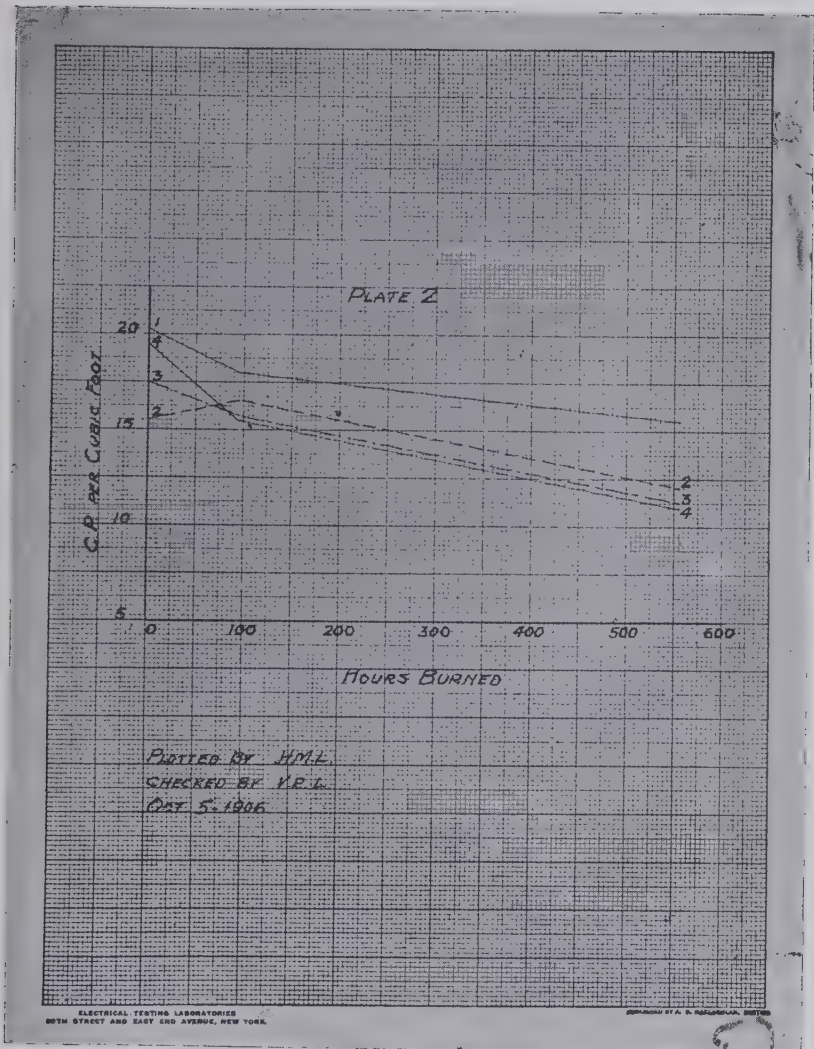


PLATE 2
C.P. PER CUBIC FOOT
20
15
10
5
1
2
3
4
0
100
200
300
400
500
600
HOURS BURNED
PLOTTED BY H.M.L.
CHECKED BY V.R.L.
OCT. 5. 1906
ELECTRICAL TESTING LABORATORIES
80TH STREET AND EAST END AVENUE, NEW YORK.

longer cylindrical at the bottom, the distortion causing them to rub against the cap. One thing to be carefully noted from these tests is that sometimes the cheapest mantles on the market have a high initial candle power, but that they very rapidly fall off in value. This class of mantles is largely handled by peddlers, and even by some of the gas companies in their endeavors to increase the sale of gas. The practice of putting out such mantles as these is decidedly objectionable, inasmuch as the customer, starting off with a mantle of high initial candle power, is apt to blame the gas company for the very rapid and marked decrease in light, which leads to dissatisfaction and opens up an opportunity for the electric company.

As before stated, the results of these tests are unsatisfactory. The question as to the value of mantles is a very broad and comprehensive one, and is not or should not be determined by any one individual. The question being, in the opinion of the writer, of such vital interest to the gas industry of this country, he would suggest that it is fitting for the new American Gas Institute, representing, as it does, almost the entire gas industry of the country, to appoint a committee which would thoroughly investigate the subject, the proper funds for the same to be supplied by the Institute. Complete tests would be too expensive for one individual or company to carry on, over 100,000 cubic feet of gas being used in the tests given in this paper, while if shared equally by those who are interested, namely, by the members of the Institute, the pro rata cost would be small. Further, if such tests were conducted individually, they would lack the authority which would be given them by being conducted by the Institute.

A similar committee was appointed some years ago by the National Electric Light Association to investigate different forms of illuminants, especially arc lights for street lighting, and the results of those tests were of great benefit to the members of the Association and the industry as a whole, and remain today the standard in this country. Would it not be possible for the Gas Institute to employ competent engineers to carry on such tests, so that the whole gas industry would reap the benefits. At the same time this would remove all questions of commercial bias. It might even be possible to establish a

permanent laboratory under the auspices of the Gas Institute, where mantles selected from any given purchase could be sent and tested, such a laboratory to fulfill in the gas field the same place as the Electrical Testing Laboratories fulfill today in the electric field. Such a committee could undertake to standardize a set of tests or specifications which mantles of a given price or quality should undergo. The writer would tentatively suggest that such a committee consider the following:

1. The initial candle power on a standard gas, at a given pressure and with a given consumption, should be not less than a stated amount.

2. The life of a mantle should be a stated number of hours before it falls to a given percentage of its initial candle power.

3. A mantle should undergo a jar test to prove its mechanical strength. A standard jar test could be easily arranged, so that all mantles would be subject equally to such vibrations.

4. The method of support for mantles should be stated. Tests could probably be conducted to determine the best method of support.

5. The weaves of mantles could be specified. Complete tests would undoubtedly show which weaves are best adapted for different conditions.

6. The amount of shrinkage during the useful life of a mantle should be distinctly specified, in order to prevent binding at the skirt, etc., with consequent breakage.

7. The question of shape both before and after burning off should be carefully considered, as many mantles fail from such causes.

8. The question of color should be carefully considered, and specifications should state the color required, as different colored light is required for different purposes.

If rigid specifications with a penalty clause were adopted by gas companies, and the Institute or some standard laboratory could conduct such tests, it would be possible to select, say one mantle at random out of each thousand, with the understanding that such a mantle represents the thousand. If such a mantle falls below requirements, the entire lot would be penalized.

If the large gas companies could buy mantles on some such

scheme of specifications, and see to it, as far as possible, that the customers were supplied with such mantles (which, of course, the gas company could guarantee), the writer believes that it would do as much toward popularizing the use of gas as any other method now available, and he respectfully suggests that the American Gas Institute appoints a committee to further investigate the situation.

DISCUSSION.

THE PRESIDENT: Gentlemen, you have heard a most valuable paper. It is before you for discussion and comment.

MR. EGNER: Mr. President, I shall have to start the ball rolling, as I have done many times before. It was my suggestion, more than eighteen years ago, when I suggested something of this kind in a paper to the Western Gas Association. I am glad to see the topic taken up. The American Gas Institute is organized for such things as this paper suggested, and there should be some united action on the part of gas companies or their representatives to furnish the funds to do that. Our annual dues were not sufficient for that, but at that time inquiries were made to see if the gas companies would contribute. That has been done by the General Association of Gas Engineers in Germany. The gas companies contributed a certain sum, and have built an experimental gas works, in which there is a water gas apparatus, a coal gas apparatus, and all sorts of scientific apparatus to make tests such as are suggested in this paper in regard to mantles. I suppose, as I just remarked, that that is one of the principal objects in organizing the American Gas Institute—to investigate just such subjects. I hope somebody will be able to elaborate what I have said. I have started the ball rolling.

THE PRESIDENT: Gentlemen, there is an opportunity, if you want to get at a standard of specifications for mantles. It seems to me that this paper should be thoroughly discussed. Now is the time to start it.

MR. W. H. GARDINER, JR.: I would move that Mr. Lansingh's paper, together with the recommendations therein,

be referred to the Committee on Candle Power, to be appointed by the Chair.

Motion seconded.

THE PRESIDENT: Gentlemen, it has been moved and seconded that this paper be referred to the Committee on Candle Power, which is to be hereafter appointed by the Chair.

MR. A. S. MILLER: Mr. President, before this is disposed of in that way, I would like to make one or two remarks in regard to the rather alarming tone which part of this paper carries with it. I am now an electrical man as well as a gas man, and I feel that I can speak from an unbiased point of view. In the first place, Mr. President, the comparison of gas and electricity here is not fair to gas. In the second paragraph, on the top of page 138, the writer speaks of the average as being three and one-half watts per candle for current conditions, or 3.1 under exceptional conditions. He also says it is three and one-half or four feet for sixty candles. Now 3.1 watts per candle is a laboratory condition. It does not prevail in practice. The incandescent electric lamp as well as the Welsbach lamp goes down in candle power from its installation. As a matter of fact, I should say there are very few electric companies in this country which are furnishing their customers with 3.1 watt lamps. They do not hold up to any such efficiency. The Welsbach lamps are averaging twenty candles to the foot, but very few of the electric lamps are averaging 3.1 watts to the candle.

Reference has been made also to current being sold for three cents. Probably all of us can remember that gas has been sold for 35 to 50 cents, and I can say that current has been sold in Baltimore under some conditions at a rate of three cents, but current is not sold for the purpose of lighting at that price in Baltimore. I do not know where it is sold for three cents for the purpose of lighting unless it is in connection with large power contracts which are taken under very exceptional conditions, and I think very few at that price. I do not think that any very large amount of current is sold in this country for eight cents.

Mr. Gartley: Mr. President, in connection with this motion which has been made, I understand we are now discussing the question of referring this to the Committee on Candle Power. Does Mr. Gardiner mean the committee on photometrical work which was suggested yesterday?

Mr. Gardiner: Yes, sir.

Mr. Gartley: I hope, gentlemen, in view of that, that you will think over this matter carefully. I am afraid that the result of combining the two investigations, which are not related to each other, would be to lessen the value of the work of the committee in either direction. As Mr. Lansingh has pointed out, an investigation of this kind would require much time and cost considerable money. I hope that Mr. Gardiner will consider that the work of the Committee on Photometrical Methods will have all that it can do without adding this to it.

Mr. W. H. Gardiner, Jr.: I worded my motion, in such a way, having in mind that it would be impossible for a committee of the Institute perhaps to undertake active work on this during the forthcoming year, but I thought if Mr. Lansingh's paper were referred to this committee, which is a directly allied subject, that that committee would perhaps be the best equipped to consider the matter very carefully and report to the next meeting of the Institute. On their report, such action as seemed advisable might be taken. However, if Mr. Gartley would prefer it, I am very glad to withdraw my motion.

The President: Are there any other remarks, gentlemen? If there are no other remarks, I will put the motion that this paper be referred to the committee. All in favor of the motion as stated will signify by saying "Aye." Contrary minds, "No." The Chair is in doubt. The "Ayes" will please arise. Gentlemen, I shall decide it in the negative. The "Noes" have it.

Mr. K. M. Mitchell: Mr. President, I move that a vote of thanks be extended to the author of that paper for his very valuable work. I think that that paper alone is worth the trouble of coming here.

Motion seconded.

THE PRESIDENT: Gentlemen, you have heard the motion made by Mr. Mitchell. All in favor will signify by saying "Aye." Contrary minds, "No." The motion is carried.

Mr. Lansingh, you have the thanks of the American Gas Institute for your paper.

Now, gentlemen, if it is agreeable to the members present, we will have a recess for a few minutes while the photographer gets in his work.

Flashlight picture taken of the convention by a photographer.

THE PRESIDENT: Is the Nominating Committee ready to report?

MR. PRATT: Yes, sir.

REPORT OF COMMITTEE ON NOMINATIONS.

CHICAGO, ILL., Oct. 18, 1906.

To the Members of the American Gas Institute:

Your committee to which was assigned the duty of nominating officers for the first and ensuing year of this association have had an unusual task before it, and has labored diligently to place before you a list of men that, in its judgment, will meet with your approval. The greatest difficulty we have had to contend with has been that there is so much good material to select from, and without the advantage that has existed in other associations before, to-wit: the rotation of men in office.

In the selection of a man for president we have been guided by what we believe would be for the best interests of the Institute at this time, a man who would combine all the elements necessary to set the wheels of the association in motion in such a way as to indicate what the future of this association is to be.

The vice-presidents are men well fitted to carry on the work thus outlined.

In the naming of a secretary the committee did not feel that it was competent to decide upon the merits of a permanent secretary at this time, believing that the decision of the Institute with respect of a permanent headquarters during the

year would assist in the solution of such permanent official; but it does recommend a man who has had sufficient experience in association work to fill that important position for the year, at least.

The choice of treasurer has fallen to one also of large experience in association work, for it seems to your committee that in the further organization of this Institute, with its large and growing membership, and the work that will undoubtedly be laid out for the association requiring the assistance of an active and energetic treasurer, that such a man would be required, and your committee suggests that the treasurer have charge of the membership list.

In the choice of ten (10) directors, five (5) for one year and five (5) for two years, your committee has distributed the honors as carefully with respect to locality as seemed advisable, having in mind the assistance their individuality and interest in the association work would give.

The committee to which was assigned the duty of nominating officers for the ensuing year has devoted considerable time and thought to this duty, and begs leave to report as follows:

For President, Walton Clark, Philadelphia, Pa.

For First Vice-President, Charles F. Prichard, Lynn, Mass.

For Second Vice-President, Henry L. Doherty, Denver, Colo.

For Secretary, James W. Dunbar, New Albany, Ind.

For Treasurer, Thomas C. Jones, Delaware, Ohio.

Directors to serve for one year: John Williamson, Chicago, Ill.; William H. Bradley, New York, N.Y.; Thomas D. Miller, New Orleans, La.; William A. Wood, Boston, Mass.; W. B. Cline, Los Angeles, Cal.

Directors to serve for two years: Frederick H. Shelton, Philadelphia, Pa.; James T. Lynn, Detroit, Mich.; H. D. Whitcomb, Jr., Newark, N. J.; L. L. Kellogg, Sioux City, Iowa; F. W. Stone, Ashtabula, Ohio.

Respectfully submitted,

EDWARD G. PRATT,
ANDREW K. QUINN,
JNO. D. MCILHENNY,
E. G. COWDERY,
Committee.

MR. KEPPELMAN: Mr. President, I move the adoption of the report of the Committee on Nominations.

THE PRESIDENT: I think the proper way would be to incorporate in that authority for the Secretary to cast the ballot.

MR. D. McDONALD: I arise, Mr. President, to move that the report be accepted, and that the Secretary cast the ballot.

THE PRESIDENT: The Secretary is one of the nominees. Make it that the Chairman of the Committee shall cast the ballot.

MR. KEPPELMAN: Mr. President, I will incorporate that in the motion.

Motion seconded.

THE PRESIDENT: Gentlemen, it is moved and seconded that the report be accepted, and that the Chairman of the Committee be authorized to cast the ballot of the Institute for the election of these officers. Are there any remarks? If not, all in favor of the motion as stated will signify it by saying "Aye." The motion is unanimously carried. It is unnecessary to call for contrary minds.

Mr. Pratt, will you cast the ballot for the gentlemen named?

MR. PRATT: Mr. President and Gentlemen: In accordance with the instructions given me, I hereby cast the ballot of the American Gas Institute for the officers and directors for the ensuing year as read in the report of the Committee. It is hardly necessary to read them again; I will do so if it is your desire. If it is not your wish, then I cast the ballot of the Institute for the officers and directors as read.

Loud calls for a speech from Mr. Clark.

MR. WALTON CLARK: Mr. President and Gentlemen: I am truly very much embarrassed. You have given me an honor that I feel deeply. Perhaps I do not appreciate it, but, I assure you I feel it very deeply. I do appreciate the responsibility you have placed upon me, and which it is, indeed, an honor for any man to be called upon to bear. It is my hope that my words and actions in this position will meet with the approval of you, my personal friends, and my

professional brethren and peers. If a man in any line of work has not the approval of those who know his job, who know what he has done and is doing at his job, then he is not a success. I want that success which will be indicated by your approval of the way I bear the responsibility you have put upon me. There is nothing nearer my heart than to do the work of this position so that you who know the work shall say that, within my ability, I have done well. I will make every effort during the year to meet your hope, and to satisfy my own ambition, which as I have just repeatedly said, can be satisfied only by your approval.

THE PRESIDENT: I am sure we would be glad to hear from Mr. Prichard.

MR. PRICHARD: Mr. President and Gentlemen of the Institute: I want to assure you that I appreciate the honor which you have bestowed upon me, and I thank you for it. For many years I served on a board of directors presided over by an old gentleman, who was a philosopher and an orator. When we elected him, as we did from year to year, it was his unvarying practice to rise from his chair and say: "Gentlemen, I appreciate the honor, I thank you for it." It seems to me that there are no words in the English language, if spoken from the heart, which expresses the thought any better. I appreciate the honor and thank you for it.

Call for Mr. Doherty.

THE PRESIDENT: I think that Mr. Doherty is not here. Is Mr. Shattuck in the room? Will you read your report now, Mr. Shattuck? We are ahead of the program, but if you are ready we would be glad to have you make it now.

MR. SHATTUCK: Mr. President, this paper is a compilation of a lot of formulas. I do not think it would be very interesting to read it, and I would suggest that I do not read it.

There have been no radical changes in high pressure distribution within the last year. Several elaborate tests have been made to try and prove out the best formula to use. At St. Louis the tests all indicated that the Cox computor was perfectly safe to use. The actual results of the tests showed

that the large sizes of pipe followed very closely the results of the computor, but that the delivery of the smaller pipes was in excess of the results obtained by the computor. I think, Mr. President, that is all I can say.

(Mr. Shattuck's report can be found on pages 415 to 419 down to Article 4 on Pumping Gas.)

MR. WALTON FORSTALL: Mr. President, I move that a vote of thanks be tendered to Mr. Shattuck for his work.

Motion seconded.

THE PRESIDENT: Gentlemen, it is moved and seconded that a vote of thanks be tendered to Mr. Shattuck for his report. All those in favor of the motion will signify by saying "Aye." Contrary minds, "No." It is carried.

I omitted to state one thing, gentlemen. I would, therefore, say that the ballot of the Institute was cast for the gentlemen named in the report of the Committee on Nominations, and they are declared elected.

Do you wish to take up any more business before the noon recess? If not, a motion to adjourn is in order.

On motion, duly seconded and passed, the convention adjourned to 2 P. M.

SECOND DAY—AFTERNOON SESSION.

Convention called to order at 2 P. M., President B. W. Perkins in the chair.

THE PRESIDENT: Gentlemen, if you will come to order, Mr. Kellogg has a matter which he wishes to present.

MR. KELLOGG: Mr. President and Gentlemen—The Iowa District Gas Association held a meeting yesterday and appointed this committee, and authorized them to frame an application to become affiliated with the American Gas Institute, in accordance with Section 49. Of course, we do not expect this meeting of the Institute to take formal action, but we would like to put in the application, or to set it in motion, so that we may know as early as possible what will be required of us. The Iowa

District Gas Association covers the states of Iowa, Nebraska and South Dakota. Our constitution is similar to the American Gas Light Association. We have not solicited membership outside of that territory, and we practically have not solicited any membership except among those engaged in the business. We would like to have this put in motion, so that we may organize the work along lines which will be in harmony with the American Gas Institute.

The application is as follows :

American Gas Institute :

GENTLEMEN—The Iowa District Gas Association desires to become affiliated with the American Gas Institute as provided in Article 49 of the constitution, and formal application is hereby made.

IOWA DISTRICT GAS ASSOCIATION.

L. L. KELLOGG,
JANSEN HAINES,
GEORGE McLEAN,
E. G. PRATT,
Committee.

THE PRESIDENT : Gentlemen, I think that that would go properly directly to the Governing Board, and if that is the sense of the meeting we will refer it to that Board, and it will be taken note of.

Your formal application, Mr. Kellogg, I think, should be filed. I think, with the consent of the meeting, we will consider that referred directly according to our new by-laws.

MR. WALTON FORSTALL : Mr. President, if this is the proper opportunity, I have some results of tests of "A" meters that I would like to present, so as to get it into the record. I will not read the paper. It simply gives the results of some tests which have been made, and I call attention to them, and ask for permission that they be printed in the proceedings.

THE PRESIDENT : By the consent of the meeting, we will have these incorporated in the minutes, provided there is no objection.

Des Moines, Iowa.

RESULT OF TESTS OF "A" METERS, JANUARY, 1906, TO SEPTEMBER, 1906.

Number of "A" meters in service	283
Number of "A" meters removed and tested	67

PERCENTAGE.

Cease to record	(1)	0
Will not pass gas	(1)	0
Error 1% fast or 1½% slow or under		61%
Error between 4% and 1% fast or 1½% slow		12%
Error over 4%		24%
Average error of all meters		2.37%
Average error of fast meters		2.16%
Average error of slow meters		.21%
Net error: *Fast*		2.00%

Meters in Service		Meters Tested	
Size	No.	Size	No.
5-A	283	5-A	67

Philadelphia Gas Works.

RESULT OF TESTS OF "A" METERS, OCTOBER, 1905, TO SEPTEMBER, 1906.

Number of "A" meters in service	878
Number of "A" meters removed and tested	114

PERCENTAGE.

Cease to record	2%
Will not pass gas	3%
Error 1% fast or 1½% slow or under	66%
Error between 4% and 1% fast or 1½% slow	17%
Error over 4%	12%
Average error of all meters	1.9%
Average error of fast meters	2.4%
Average error of slow meters	2.3%
Net error: *Slow*	1.2%

Size of A Meters in Service		Size	Tested
5-A	604	5-A	76
10-A	80	10-A	12
20-A	5	20-A	2
30-A	159	30-A	20
60-A	21	60-A	3
150-A	9	150-A	1

Kansas City, Missouri.

RESULT OF TESTS OF "A" METERS, 1905 TO SEPTEMBER, 1906.

Number of "A" meters in service	6255
Number of "A" meters removed and tested	518

PERCENTAGE.

Cease to record	8	128/1000%	1.28%
Will not pass gas	12	192/1000%	1.92%
Error 1% fast or 1½% slow or under	235		45.4%
Error between 4% and 1% fast or 1½% slow	190		35.7%
Error over 4%	73		14.00%
Average error of all meters			2.31%
Average error of fast meters			1.84%
Average error of slow meters			2.44%
Net error: *Slow*			1.29%

Meters in Service		Meters Tested	
Size	No.	Size	No.
5-A	6139	5-A	516
10-A	85	10-A	2
20-A		20-A	
30-A	11	30-A	
60-A		60-A	
150-A		150-A	

The President: I think we can hear from you now, Mr. Williams. Are you ready with your report on Novelty Advertising and New Business Methods?

Mr. George Williams: Mr. President and Gentlemen:

The program calls for a description of the new business methods department conducted by the Ohio Gas Light Association. As a great many of you are familiar with the work of that department in the Ohio Association, which was for several years in charge of and developed by our president, you remember how it has grown from year to year. Five or six years ago Mr. Perkins had considerable labor to induce thirty or forty contributions, but the contributions have increased and developed from that to several hundred.

Last year it was decided by some of those interested in the Ohio Gas Light Association to collect these contributions on new business methods from various managers all over the country, and publish them in book form so that they would be accessible to commercial men, solicitors, representatives of gas companies, and others who are interested in the gas business other than in a technical way.

It was decided to again publish contributions for the American Gas Institute, and within ninety days it has been possible to get together this excellent collection of contributions which represents the experience of about three hundred gas companies, who are interested in the promotion of gas sales. (American Gas Institute New Business Methods Report distributed.)

The title of "editor" of this department is somewhat of a myth. The editorials, you will note, were written by men who are well known to you, and many of them by gentlemen who are present.

Following these are the examples of newspaper advertising and magazine advertising, of booklets and circulars, etc., which are reproduced with the idea of assisting many who desire to get up such literature, examples of circular letters are also given. Another feature of the work is the illustration of several up-to-date salesrooms, something that we consider very necessary nowadays.

The last section of the book is that "undignified" portion

The published report of the Novelty Advertising and New Business Methods as presented by Mr. Williams was a contribution from the Ohio Association and on account of its length it is not included in the Institute Proceedings. A copy can be obtained from the Cantwell Printing Co., Madison, Wis.

which was under discussion yesterday morning, to-wit:—the advertising section, but which you will find very interesting.

I want to take this occasion, Mr. President, to heartily thank the contributors to this report, many of whom are present, for their kindly support in getting out this volume.

THE PRESIDENT: Gentlemen, you have heard the report submitted by Mr. Williams. Are there any comments or questions to ask in relation to this? If so, we would be glad to hear them. I think that Mr. Williams deserves great credit for the work that he has done in this direction, and for the very efficient way in which he has compiled this book. It has been put in a form so that it will be very easy to refer to hereafter. It is a text-book practically on advertising, and he certainly deserves a vote of thanks from the Institute for the work which he has done. I would be pleased to entertain such a motion.

MR. HORTON: Mr. President, I move that a hearty vote of thanks be extended to Mr. Williams for the preparation of this report.

Motion seconded.

THE PRESIDENT: Gentlemen, it is moved and seconded that Mr. Williams be accorded a vote of thanks for his very efficient work on new business methods.

MR. SHELTON: Mr. President, I suppose that in connection with that the question comes up as to the continuance of the New Business Department.

THE PRESIDENT: I think it is understood that it is to be continued.

MR. SHELTON: I think it ought to be left in a little more definite way than merely understood. I think the sense of this meeting ought to be expressed in such a way that it will amount to something. I am heartily in sympathy with the work of this Progress Department. It is a work of great practical use, and something that will be constantly referred to, and I would suggest that the matter of its continuance be referred to the Directors with power to act, in much the same way that the question of the continuance of the Question Box

was left to them. I think it ought to be specifically put in the hands of the Board of Directors with power to control it and yet push it.

THE PRESIDENT: I will ask the original mover of the vote of thanks to incorporate that in his motion with the consent of the second.

MR. HORTON: I shall be very glad to do so, Mr. President.

THE PRESIDENT: It is moved and seconded that Mr. Williams receive a vote of thanks, and that the matter be referred to the Board of Control with power to act, with a recommendation for the continuance of the work. All in favor of the motion as stated will say "Aye." Contrary minds, "No." The motion is carried. Mr. Williams you have the thanks of the Institute for your very efficient work.

Is Mr. Welch in the room? If so, we will hear from Mr. Welch.

In connection with the reading of the paper Mr. Welch gave a series of very interesting and instructive lantern slide pictures illustrating the work.

EXTINGUISHING THE FLAME OF A 600 POUND PRESSURE, MILLION FEET HOURLY CAPACITY NATURAL GAS WELL.

The Vanderpool Well No. 1, of the New York Oil and Gas Company, was drilled into the gas bearing sand on the 19th of February last, at a depth of 1,430 feet. The Bartlesville sand had been passed through at a depth of 1,260 feet and had been dry. The well had been drilled for oil and when none was found in the Bartlesville sand the drilling had been continued, in the hope of striking either gas or oil at a lower level. It was expected to strike the Mississippi Lime sand at 1,500 feet. As the well was, in a measure, a wild cat one, there had been no thought of getting such a large volume of gas at the depth at which it was found. It had been decided to case the hole with 6¼ casing and continue with a six inch hole for the

The illustrations in this paper are used by permission of Harry Talbott, Independence, Kas., Photographer.

balance. The last "screw" was being run before pulling out for this purpose when the gas sand was reached. There was in the hole, at the time operations were abruptly terminated, about 360 feet of 8¼ casing and one or two joints of ten inch. At the top of the 8¼ was the customary drilling nipple or pipe with its top belled out to prevent the drilling cable cutting on the rough edges.

Casing with 6¼ had been decided upon as a contingency against the walls of the hole caving and filling it up or burying the tools. Before the remaining two or three feet necessary to run out the "screw" had been drilled, the gas was found. The drilling was immediately stopped, the tools taken from the hole, and preparations made for closing in the well. On account of the gas being unexpected the necessary fittings were not on hand. Instead of using the 6¼ casing it was now decided to tube the well with 6 inch pipe and set a "packer."

What material is put in a well depends upon the local conditions, as to water and nature of dirt drilled through. In this case if the 6¼ casing had been set there probably would have been no further difficulty with the well, as it could have been easily tubed with a 3 or 4 inch tubing. Tubing with the 6 inch was a more difficult matter, and several packers were destroyed in making the effort to set them.

Finally, on the afternoon of February 23rd, when the successful closing in of the well seemed to be assured, with eleven hundred feet of 6 inch tubing already in the well and only a couple of hours work ahead, a very severe electrical storm came up, almost the first of the season.

The flashes of lightning kept playing closer and closer, until finally Mr. J. M. Landon, field manager in charge, who was at the well at the time, ordered the men to leave the derrick and seek a safe place. As was soon demonstrated, with momentary danger of fire, and gas coming from the well at the rate of more than a million cubic feet per hour, the spot was not a safe one.

Within five minutes of the time the two men who were working forty feet up the derrick came down, and all left, almost before they had got under the shelter of some nearby

trees, and while all eyes were turned in the direction of the top of the derrick and the clouds above, there was a flash and a clap, and they saw descending one great column of fire, wide at the top and narrowing at the bottom like a funnel. Instantly the derrick was on fire and burned to the ground. Two joints, or forty feet of 6 inch pipe had been left rising out of the hole, and from the top of this there flashed forth a burning jet of gas one hundred and fifty feet into the air. Such was the force of the flow that the flame was held off from the mouth of the casing at least fifteen feet.

My first impression of the well on the second evening following the day of its taking fire is hardly describable. A number of us who had gone there, some as disinterested spectators and others with a view to considering the problem of extinguishing the fire, walked to within probably seventy-five feet on the windward side. I approached the well cautiously having a decided feeling that there was considerable danger in getting too close; yet upon consideration I knew that there could be very little danger in going as near as the heat would allow. There was no danger of an explosion, as already all the gas was being burned; there was no danger of the flames catching us, as the force of the pressure in the well was sending them skyward with intense fierceness. Yet the great roar, the tremendous flame shooting forth with a power never before contemplated, filled one with awe and fear. This, however, wore off after one or two visits.

At night the scene was very beautiful, as if some wondrous torch 150 ft. high, were blazing forth. The trees and bushes near the well cast vividly sharp shadows and in fact for several miles distant, distinct shadows were visible. The reflection of the flames on the clouds, on a dark night, could be seen for fifty miles or more; and with a favorable wind, the roar could be heard for at least ten miles.

This was the task confronting us: The fire must be put out, and as soon as possible; yet so great a fire had never been mastered before. The problem was a new one and a big one, yet it must be solved. It was not only a problem of extinguishing the fire, but, at the same time, of protecting the well;

for after the fire was out the gas must be confined or controlled; since if this were not accomplished there could be no object in extinguishing the fire. Therefore, not to damage the material in the well was a primary consideration throughout the work.

The work of our company is done by departments. The Field Department to which this well belonged was in charge of Mr. J. M. Landon, with Mr. Thomas Gavin as Superintendent.

Ordinarily each department works out its own salvation; but this was no ordinary matter, and a general conference resulted. As engineer of the company and head of another department, I took part in the undertaking from the first, and as soon as he was able to do so, Mr. J. C. McDowell, our General Manager, who has probably had more experience than any other man in the gas or oil business in extinguishing large fires, joined us in the working out of the problem. In this connection I would like to say that to Mr. McDowell, more than to any other man, should go the credit of the final mastery. From the time he reached Caney, but a few days after the well was fired, until the last little puff and flicker of flames, when he saw the successful culmination of five weeks of the most trying physical and mental experience, he was with us. His persistency, his energy, patience and encouragement, all were potent factors in snuffing out, even as a candle is snuffed out, (and apparently as easily when it was finally done), undoubtedly the largest volume of flame that was ever extinguished.

Upon my shoulders fell the duty of providing the apparatus. On the day following the starting of the fire Mr. Landon and myself designed a hood. We then had a very poor realization of the task before us. This hood was duly made and sent out to the well. It arrived on the ground, I believe, about daylight, and we were on hand shortly after. This hood was made of about ⅛-inch sheet iron riveted, and was much the shape of a cow bell with a 6-inch opening in the flat top and an 8-inch opening on the side. We looked at the well, then at the hood, and agreed without further consideration that hood number one would not do.

A method of putting out gas well fires, by which the flame is smothered by means of jets of steam, has been successful in many instances. Therefore nine boilers, such as are used in the oil and gas fields for drilling wells, were gathered in and set at points surrounding and near the well. Two inch steam lines were run up to the mouth of the well. Steam was raised to a pressure of about one hundred and twenty pounds, and at a signal eighteen jets of live steam were turned loose. One might as well have hoped to dam Niagara as to put out that fire with steam. No impression whatever was made, and, after one attempt, steam was abandoned. It was early decided that the two joints of six-inch pipe which projected above the surface would have to be removed. This was accomplished much more easily than was anticipated, as it was only necessary to throw a line around the top and bend the joints through an angle of forty-five degrees. By means of this same line it was then a simple matter to unscrew the pipe from the collar close to the surface of the ground.

One of the features of the fire which caused us untold trouble, inconvenience and physical discomfort, was that the flame was divided. The bulk of it was caused by the gas coming through the six-inch pipe and going straight up; the balance of the flame was from the gas which came up on the outside of the six inch and inside the eight and a quarter. This gas, striking the elevators which were supported on the top of the 8¼ and were clasped around the 6 inch supporting the eleven hundred feet of it which had been lowered into the hole when work was stopped on the afternoon of the thunder storm, spread in four separate secondary flames which shot out in a horizontal direction for distances varying from ten to twenty feet. These flames did more to prevent our near approach to the well than the very much larger body of flame which went directly upwards.

The question whether the 6-inch pipe should be allowed to drop to the bottom of the well, a distance of over three hundred feet, by releasing the hold of the elevators, thus throwing the flames together in one large ascending volume and perhaps destroying the well, or whether it would be possible to accomplish the end we were working for without running the risk of

sacrificing the well, was a mooted one. It was decided that not until every effort had failed should we drop that string of six inch.

Our next conference, after trying the steam, resulted in a course which was adhered to from that time on, although we modified our methods of handling the material somewhat. Between the next hood, which was destroyed, and the one which was finally successful, there was no difference in design.

The second hood was made of ¼-inch boiler plate riveted and made in the shape of a cone. It was three feet in diameter at the base and probably six feet high. At about four feet from the base a break in the cone occurred, and from that point the cone narrowed more quickly toward the center. Actually the hood consisted of the frustrums of two cones of different angles, one placed upon the other. Into the top of the smaller cone was riveted a short piece of 12-inch screw pipe, and on this was a 12-inch tee, placed with the length of the tee in a vertical position. Above the tee was a nipple, a 12-inch gate valve, and another short piece of pipe. Into the side of the tee was secured a 12 x 10 swedge nipple, about three feet long, and from this was carried a number of joints of 10-inch screw pipe. To handle this hood and its long tail of 10-inch pipe, we built a crane made of 6-inch steel pipe. The crane consisted of a mast fifty feet high and a boom of approximately the same length. Both the mast and the boom were heavily trussed to give strength, and everything about the crane was made either of steel or of iron.

Within two days and a half from the time the hood and the crane were decided upon they were both on the ground ready for the work; but to accomplish this a boiler shop and two machine shops were kept working day and night and two special trains were chartered to deliver the material as soon as it was ready to leave the shop.

On account of the cumbersome string to the hood, consisting of one hundred and fifty feet of ten inch pipe, it was thought that it would be necessary to fix the boom of the crane so that it would not swing in a lateral direction. A grade was established and about one hundred and twenty feet of track laid toward the mouth of the well. A car was built

and the mast of the crane mounted upon it. It was proposed to lift the hood from the ground with the boom and then to advance the entire outfit, mast, hood, tailpipe and all until the hood was directly over the mouth of the well, when the hood would be quickly lowered. We were able to advance in this manner for a distance, but the downward thrust on the track was very great. Our road bed was new and therefore not well packed. The result was that a wheel jumped the track and we broke an axle. Our hood was then probably forty feet from the well and our mast ninety feet away. It was, however, uncomfortably warm working even at the greater distance from the well, and we decided that it would be impossible to build a suitable track to the necessary distance from the well. It was also a difficult matter to keep the mast in a vertical position and at the same time advance it, as that meant a slacking off on our rear guy lines and a tightening on our forward ones. It was decided to place the mast in such a position that it could be permanently located. This necessitated the swinging of the boom sideways and the swinging of the tail pipe. To accomplish this a swing joint was inserted in the line. This necessitated the introduction of several ells and considerable friction resulted. These ells were later taken out.

It was on Sunday, March fourth, that the plans for the second hood and crane were decided upon. On Tuesday morning at five o'clock our special train started from the siding of the boiler shop at Independence, with the hood on board, and on Tuesday at midnight the completed crane was placed upon a special train at Chanute. By Thursday the crane was erected, the hood in place on the track which had been built and the entire apparatus was moved forward as above described. It was after advancing a considerable distance that our wheel jumped the track and the axle broke. At this time the movable truck was abandoned and the mast made stationary at such a distance that the boom would be able to successfully land the hood over the well. The boom was then swung to one side and preparations made for the first trial. Accurate measurements were made so that when swung into position the centre of the hood might be directly over the center of the well. The exact measurement from the well to

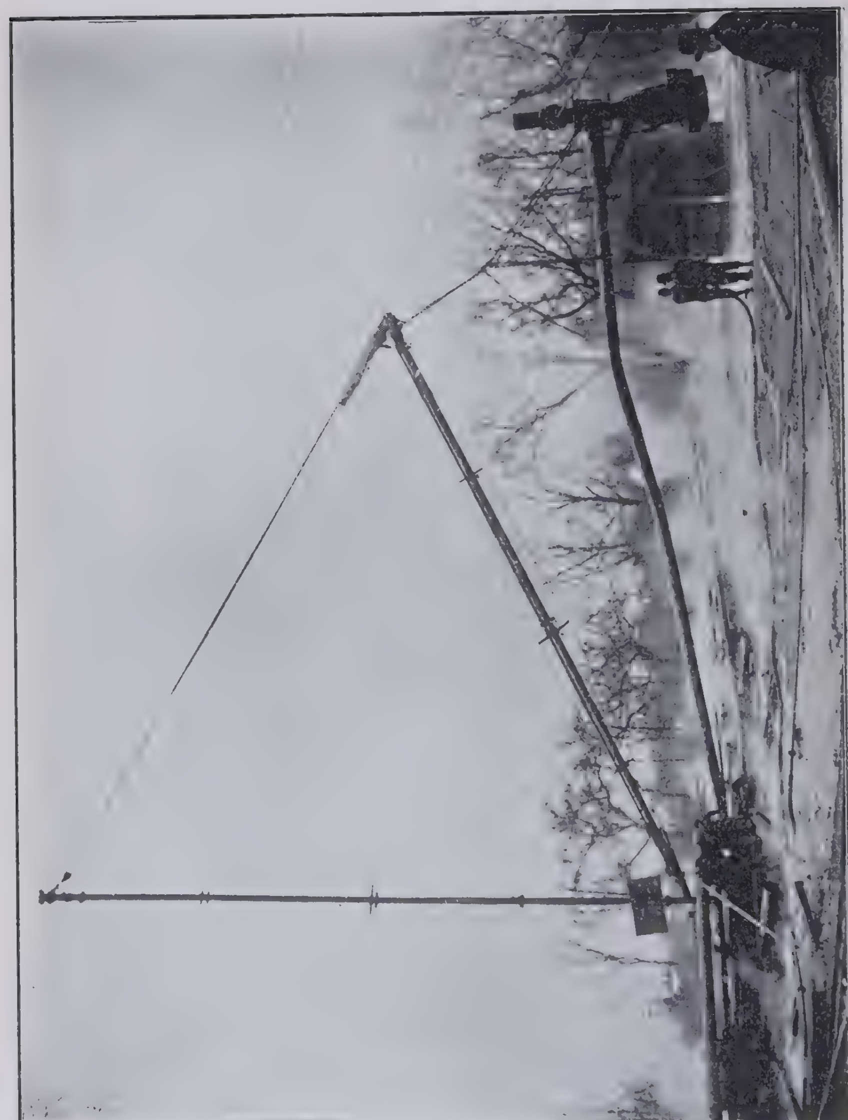
the mast was fifty-seven feet. The boom was only forty-nine feet long so that it was necessary to fasten from the end of the boom to the ten inch pipe and allow the hood to extend about eight feet further out. This was an advantage, as the weight of the hood balanced the weight of the ten inch pipe and made it easier to swing around.

There was considerable suppressed excitement as the final preparations were made to "cap the well." There was more or less speculation as to what the effect would be when the hood came into the current of the gas as it shot with its irresistable force from the pressure reservoir lying hundreds of feet below the surface. The roar of the well was terrific and all communications had to be either written or yelled at the top of one's voice into the ear of the person spoken to; and even to do this it was necessary to withdraw to a considerable distance from the well.

At last the various crews were placed and instructions given them as to what their duties were to be. A code of signals was adopted and one man was to be stationed at some point from which he could direct the movements of the others. One crew was placed on the "crab" used for raising or lowering the hood. Another crew was to pull the hood into place by means of a guy line attached to it. Another crew was to hold back on the hood by another guy line in the opposite direction, to prevent the first crew from pulling too fast and to stop the hood when it was in position.

A signal to the crew at the "crab" lifted the hood gradually from the ground, and a second signal started it slowly and cautiously towards the well. Everything worked beautifully. The crowd of spectators was ordered back to a safe distance. Instructions had been given that the hood should be carried to within fifteen or twenty feet of the well and there held for a final signal to proceed, as it was thought that it might be necessary to take some further precaution to insure its successful landing. There seemed to be nothing further to do. The apparatus was working smoothly, and as planned. The final signal was given to go ahead. The tension was great. What was about to happen could not be predicted. Whether our hood would be tossed into the air by the force of the gas and

landed somewhere, a bent and broken mass, or whether it would settle gently down into position as we hoped, we could only surmise. Eagerly we watched the result, but our hopes for success on the first trial were not to be realized. As the edge of the hood was caught by the ascending column of gas, notwithstanding the fact that we had 2,000 pounds of steel billets attached to the outside of the lower rim of the hood, it swung from side to side very much like the bell of a locomotive. Several times it did this, pivoting around the thread of the pipe into the tee until the thread gave way, and our hood hung in a disabled condition in the flow of the gas. The chains from the boom still were attached, and we were enabled to drag it to one side. Thus ended our first unsuccessful attempt. A consultation followed at the hotel that evening. We were not discouraged. We could not be. We must try again. A plan was devised which would prevent a similar recurrence. Braces were made, and in a day or two we were again ready. By Monday, March 15, two days after the first attempt and failure, we had put a harness on the hood which would hold it as we wanted. Monday afternoon, at about four o'clock, we had our hood squarely over the well. Our apparatus worked perfectly, and we were very much elated over our apparent success. On account of the unevenness of the baked ground close to the well, and also on account of those troublesome secondary flames which hissed out at us from every side we were unable at first to confine all the gas to the hood, and we had to fight a fire coming from the bottom. A large gang of men was put to work piling gumbo and dirt around the base of the hood. By this means we were enabled to stop the leak round the bottom, and at about nine o'clock that evening, when we decided to call it a day's work well done and to go home for our dinners, and a night's rest, the scene which we left was one of the most satisfying I ever witnessed. Where but an hour or two before, from a piece of pipe extending a few feet above the ground, had hissed forth lurid tongues of flame, apparently beyond the control of any human agency, we now saw a huge mound of earth covering our hood, from the top of which there rose majestically, seemingly under perfect control, a huge column of fire. Now



it seemed that there remained but to close the gate valve in the top of the hood and our work was done. For several hours we had worked close to the hood, and with one or two others I had climbed to the top of that pile of earth (a veritable volcano it was, but in our enthusiasm we had no fear), to examine the valve.

We had not yet sat down to our late dinner when a message came from the well to tell us that the flame had broken out from beneath the hood even worse than before. An urgent message; but as we were tired out, and as we had left a force of men to look after things, we decided to take a much needed rest.

The next morning we found, to our dismay, that our hood was a ruined, mangled mass; that our boom had been destroyed, and it would be necessary to commence again where we had been two weeks before. To add to the general wreck, the wind changed, the flames burned the guy lines of our mast, and it fell. New mast, new boom, new hood, these were what were necessary before we could go ahead again. The machine shops were again started working day and night. This time 5/16 boiler plate was used for the hood. No changes were made in the design except that a 6″ opening was put on the side of the hood as a sort of relief to the pressure. On Monday, the 19th, the new apparatus was in place ready for another attempt. By the usual method, the hood was placed over the well. By this time we had become experienced, each man knew what he was to do, and it was an easy matter for us to land it. But the gas flames, coming from underneath the edge of the hood from those side jets which had been at every turn a source of trouble, again were our Waterloo. The struggle that followed during that afternoon and evening in a vain effort to beat that flame was worthy of a nobler cause. We attempted to smother it by piling dirt and gumbo about the hood. Each man felt that it was his own personal struggle. For six hours, one shovelful at a time, we carried dirt and piled it around the hood. Crowns of men's hats were burned out, the shoulders and backs of their coats were scorched till they fell in pieces, the soles of their shoes were burned through, yet not a word of protest. They worked till

from sheer exhaustion they were compelled to retire, again to renew the attack when they had sufficiently recovered. It was all to no avail. With the experience of the first hood before us, we felt that this also would be ruined, and not waiting to get it out decided to build another hood—this time cast iron was decided upon; however, we were able to recover the hood practically unharmed. During the next few days while the cast iron hood was being made, several attempts were made, but always with the same results. Our efforts had been so handicapped by the side flames that it was decided they should be united with the main body of the flame. This could only be done by dropping the eleven hundred feet of inch casing in the hole. It was the last hope. A cannon was secured to shoot off the elevators and thus release the casing. It was at about this time discovered that the links holding the elevators had been burned off and that if they could be spread apart the pipe would drop. By this means no damage would be done to the collar at the top. A spear was made and fastened to the end of sixty feet of three-inch pipe. The elevators were spread and the casings dropped. The relief at this change in flame was marvelous. By means of over-head screens we could work with comparative comfort immediately at the mouth of the well. We were thus enabled to clear the ground away and make a level area about eight feet in diameter in the center of which was the well. We sank this a couple of feet below the surface of the surrounding ground. Water was played upon it, and the ground was kept soft. Several times the men working there allowed the tips of their shovels to get into the flow of the gas. They were thrown fifty feet in the air. The first time this occurred, the workman hardly knew what had happened. His shovel disappeared as by magic from his very hand, and he saw it no more. Once also a steel bar was hurled high into the air.

Up to this time only once had we got to the point of attempting to close the gate of the hood. We used an extended stem made of two joints of two-inch pipe for this purpose. The method was too slow, and as soon as the pressure began to increase, due to the shutting of the gate, out she broke from the bottom. The extended stem was

abandoned, and a reel placed upon the regular stem. Upon this was wound a coil of light, flexible, stranded wire. It was the intention to have a couple of the men, the fastest runners among them, take the end of the line and run with it until the gate was closed. So confident were we now of success that on the afternoon before the final effort we had a group picture taken. Every one present, including spectators, was invited to get into it. We went to our hotel that night making plans for getting away the next night. Most of us would not be needed there after the fire was out, and very little other business had been done for a month.

It was Thursday afternoon, March 29th, when we landed the hood. Not a bubble came up through the pool of water in which it was standing. The work of weighting the hood down was carefully looked after. Nothing must be neglected, for we felt that if care was exercised we were to be triumphant. Successive layers of gumbo and canvas were placed around the hood. The canvas was stretched flat, and extended twelve or fifteen feet away. Water was kept constantly playing over all. The canvas was also well soaked in water before it was put in place. One hundred feet of six-inch pipe was connected to the opening on the side of the hood and the gate valve opened. Wire cables were thrown over the hood and fastened to dead men buried deep in the ground. These were then drawn as tight as it was possible to get them. We did not dare to cut our boom free, as in the remote event of failure we must be able to lift the hood away by means of the crane; but the boom was lowered to get it as far as possible from the flame.

At about four o'clock we were ready to shut the gate. We had exhausted every available means of holding the hood down. Six hundred pounds to the square inch exerted on the inside of a cone, three and a half feet at the base has a lifting power which is considerable. When the final word to go was given to the men on the end of the wire line there was a certain degree of nervousness evident, although everybody was smiling. Two steam pipes had been hooked by means of a nipple and elbow over the top of the short piece of 12 inch pipe away from the hood and above the gate valve. If any small

leak remained after the gate was closed it was intended to snuff out the flame with the steam.

As the men started on their 120 foot dash across the field there was at first no apparent effect. Not until the discs had begun to throttle the opening was there a change. Gradually the flame grew less until finally with a puff and a hiss nothing but a column of white steam was left; but by this time things were doing about the hood. It commenced to bob up and down and dance as if impatient at the restriction upon it. There also began to be an agitation set up underneath our carefully constructed pile of gumbo and canvas until again the forces of nature predominated and the gas broke forth through our flimsy barriers. It was not ten seconds after the fire was gone until the gas enveloped the hood. But what cared we? Our fire was out. Five weeks of incessant battling with the apparently unsurmountable obstacles presented by a combination of the physical and chemical forces of nature had resulted in man's supremacy.

The rest of the story is quickly told. After a number of unsuccessful efforts to screw into the top of the six inch casing which had been dropped in the hole the well was shut in on the 8¼ casing and in that shape she stands to-day. No gas has yet been taken out of the well except for local drilling purposes and the enormous gas reserve, stands available when it is found necessary to use it.

Although this was the hardest piece of work upon which I have ever been engaged, it was also the most interesting, and although the physical and nervous strain during the entire five weeks was most severe, I would not have missed the opportunity afforded; yet I question if I would knowingly enter upon another such battle with the forces of nature.

The President: Gentlemen, you have heard the paper by Mr. Welch. What is your pleasure concerning it?

Mr. Shelton: Mr. President, I move that a most hearty vote of thanks be extended to Mr. Welch for this paper. I think the American Gas Institute is indebted to the Natural Gas Association of America, and to its representative here, for having given this paper to the Institute as a contribution

to its work. I ask that the same course be taken in this case as was suggested before.

Motion seconded.

THE PRESIDENT: Gentlemen, you hear the motion. All those in favor will signify by saying "Aye." Contrary minds, "No." The motion is carried. Mr. Welch, you have the thanks of the American Gas Institute for your paper.

MR. HENRY L. DOHERTY, as Chairman on Methods of Testing Industrial Appliances, gave an extemporaneous resume of the work done in preparing the report and some of the conclusions arrived at. In closing, he said:

"I would move, Mr. President, that this report be accepted, and that we be given leave to amend at the convenience of the Secretary, so that the report may appear in the proceedings. We do not want to delay its publication, but we want to pass it over from one member of the Committee to another, and have them all pass upon it before it is published. I make this in the form of a motion.

THE PRESIDENT: Gentlemen, you have heard the motion which has just been made by Mr. Doherty. Any remarks? Is there a second?

Motion seconded.

THE PRESIDENT: All in favor will signify by saying "Aye." Contrary minded, "No." The motion is carried. I think a little appreciation for the work which has been done on this should be shown by the Institute.

MR. WALTON FORSTALL: Mr. President, I will move that a vote of thanks be extended to Mr. Doherty for the valuable work which has been done.

Motion seconded.

THE PRESIDENT: All in favor of the motion as stated will signify by saying "Aye." Contrary minds, "No." It is carried. Mr. Doherty will please accept the thanks of the Institute.

SECRETARY DUNBAR: The report, as I understand, is in the hands of the Committee to be returned.

MR. DOHERTY: Yes.

STANDARD METHOD OF TESTING FUEL GAS APPLIANCES.

Your committee wishes to recommend to the association that its report of 1903 be amended by substituting a new report, which we think should be in the form of a detailed explanation and should be published in pamphlet form, and supplied to all gas companies and appliance manufacturers. Considerable interest has been evidenced in the work of this committee, and, on the other hand, many appliance manufacturers and gas companies have seemed to oppose it. Others seem to think that it is the wish of this committee that economy of operation should be considered of paramount importance to all other desired features in gas appliances. This is not the position of your committee, for we recognize that economy alone does not determine the value of an appliance. The degree of satisfaction of results is of prime importance, and unsatisfactory results cannot in any way be compensated for by economy. We presume, however, that no gas man will disregard in the future, or has disregarded in the past, the consideration of satisfactory results secured from appliances, their artistic appearance, workmanship, ease of repairs, ease of cleaning and durability.

Many factors which go to make up the most desirable range from a commercial standpoint are matters of opinion, to be determined by visual inspection. Economy is not so easily determined, and some of the foremost appliance manufacturers confess that they do not know the exact economy of the gas appliances they manufacture, the extent of the losses, or the division of these losses. High economy should not in any way interfere with other desirable features of gas appliances, and, as a rule, should contribute to, rather than detract from, these desirable features. Your committee assumes that every manager believes it to be to his company's interest to supply

the appliance which shows the highest efficiency consistent with other desirable features.

For the benefit of those who are not entirely familiar with this work, it may be well to state that until our 1903 convention no attempt had ever been made to establish standard methods for testing fuel gas appliances. Miscellaneous methods were in use which could only result in conclusions which failed to agree. The purpose of this work is to reduce the testing of fuel gas appliances to a condition where the same conclusions will be reached, no matter where, when, or under what conditions the investigation is made. It is also the purpose of this work to determine what portion of available heat in the gas is made to do useful work and what portion is lost. Further, it is the intention of this work that these losses shall be subdivided into their determining causes to enable the designer and the purchaser to curtail these losses, or, if possible, to eliminate them. The simplest means possible are recommended for this work, but your committee realizes that we are probably far from the best solution of these various problems. We are simply doing what we can, and asking for all the help which can be secured.

The field for gas fuel is practically unlimited, and the extent to which gas is used depends upon the aggressiveness of the management of the gas companies, the price of gas, and the efficiency and desirability of the appliances available. It is possible to materially increase the efficiency of all gas-burning appliances, and your committee believes that it is possible to open up more extensive fields for the use of additional gas in this way than could be secured by a reduction of 25% in the average selling prices of gas.

The apparatus for conducting these tests is inexpensive, but sometimes an expense must be incurred by each gas company which wishes to be thoroughly informed regarding the desirability of various gas appliances. This expense, however, is insignificant compared with the great benefit which can be secured by this knowledge. Compare, if you will, the expense of research work on this problem with a material reduction in the price you are charging for gas, and the insignificance of this expense will be made apparent.

With this explanation we will take up the detailed methods of doing this work, and it will be the aim of your committee to outline the methods it recommends in a way intended to be intelligible to the man who does not enjoy a technical education and in a way which will enable this work to be taken up by an ordinary workman without demanding more than minimum attention from the manager or engineer wishing to adopt these standard methods.

Gas Supply.

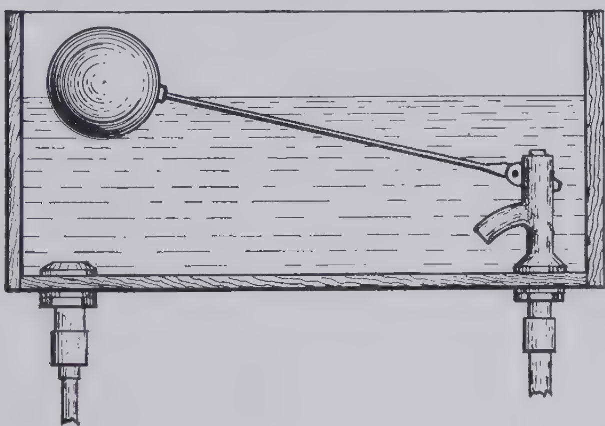
The first essential is a gas of known calorific value, and as this value is apt to vary considerably, great care must be exercised or a serious error will be introduced right at the start.

It will be found that the calorific value of the street gas varies more at certain hours of the day than at others and the tests should be run at the time when the variation is found to be the least.

The second essential is that the supply be of constant pressure, and as two inches of water is generally accepted as the desired pressure at which gas should be supplied to consumers' premises, your committee recommends that the supply of gas for testing purposes should be at this pressure. It is not, however, so important that the exact pressure recommended should be used as it is necessary that whatever pressure is used should be a constant and not a variable one.

Some misapprehension seems to exist regarding the efficiency of Bunsen burners supplied at a higher or lower pressure. Generally speaking, best results can be obtained at the higher pressures. This is due to the increased potential energy dependent on this higher pressure, which secures higher inductive effects and a more intimate mixture of gas and air, also the condition necessary for a high flame temperature. To secure these results, however, the gas must be checked only by the size and nature of the gas orifice, and where a fixed gas orifice is used and the pressure reduced by a stop-cock, no gain is secured by the higher pressure. No matter what the pressure may be behind the stop-cock, the velocity or rate

of flow of the gas through the orifice is fixed only by the excess of pressure immediately back of the orifice over that of the atmosphere, and if it is desired to reduce the rate of flow from say 20 to 5 feet, it is accomplished by reducing the pressure of gas on the orifice by partially closing the stop-cock. The velocity of the gas issuing from the orifice would be the same (neglecting the effect of eddy currents) whether this reduction of pressure is secured at the stop-cock immediately behind the orifice or at the works several miles away. Assuming that the orifice will be of constant size, the effect



FLUSH TANK.

Fig. 1.

of high pressure is therefore only manifested in the maximum velocity of the gas which will be passed by the orifice.

The space occupied by a given weight of gas will vary as the absolute pressure. Therefore the pressure to which the gas is subjected during measurement would introduce a slight error. At sea level the pressure of the gas would be 14.7 pounds per square inch, or 480 inches of water, so that a variation of one inch in pressure would only affect the measurement to about .2%, which is negligible. But the same variation in pressure would make a considerable difference in the

amount of gas passed by the orifice, that is, an appliance which is furnished with an orifice intended to pass say 35 feet per hour under two inches water pressure would, with a slight variation of this pressure, pass several feet more or less in that time, causing an increase or decrease in the temperature of the appliance under consideration, and as it invariably requires the lapse of some time to obtain constant conditions, which are necessary for a test, it is imperative that the rate of flow should remain constant. As it is seldom possible to get constant pressure unless tests are conducted at the works, it is absolutely essential that a good and reliable gas pressure regulator should be used, and for uniformity this regulator should be adjusted to deliver gas at a pressure of two inches of water.

Water Supply.

It is equally important that constancy of water supply, which is used for absorbing the heat of the gas, should be observed. It is to be desired that the water shall be supplied at constant pressure and constant temperature. The temperature of the water from city mains is usually approximately constant, provided it is not conducted through heated rooms, and even then it can generally be secured at a constant temperature by allowing it to flow for some time at a constant rate, and the variation in temperature will thus be reduced to a negligible quantity or the effect of this change in temperature can be established with reasonable accuracy.

If, however, the pressure is not constant, the requisite temperature conditions cannot be obtained, for as velocity of water flowing through an orifice being theoretically equal to the square root of $2GH$, any variation in the head H, or pressure, will cause a proportionate change in the rate of flow. As a change of velocity or quantity will change the differential temperature through the absorbing chamber of the appliance under test, this change may cause an appreciable error, for there is always more or less capacity to hold heat, and unless the test is started and stopped with the same temperature conditions prevailing, error is occasioned to the extent of the thermal capacity of the apparatus. A simple and very

effective method of maintaining a constant head is by the means of a flush tank with float valve but with syphon removed, as illustrated in Fig. 1. This tank should be placed high up in the testing room and connection made with the city service, or other available water supply, the head of which will always be sufficient to supply the tank at the height at which it is placed. The water for testing is drawn from the bottom of the tank, and the float valve admits as much water as is withdrawn and maintains the head at practically a uniform level. With this arrangement, as diagrammed, very satisfactory results have been obtained in one of the testing rooms established on the lines recommended by this committee at the 1903 convention.

Scope of Report and Classification of Apparatus.

No attempt will be made at this time to prescribe standard methods for testing the industrial gas appliances, such as brazers, forges, and tempering furnaces, the committee believing that only the standard domestic appliances can be advantageously considered at this time. Our report will therefore cover only water heaters and gas ranges, specifying methods for determining how much of the heat is usefully employed, positive or comparative methods for determining the extent and division of the losses, and explanation regarding some of these losses which are calculated to assist experimenters and possibly some designers.

For the sake of convenience, the following classification is made:

- Water Heaters
  - Circulating.
  - Instantaneous.
    - Direct.
    - Indirect.
- Ranges ......
  - Top Burner ..
    - Regular.
    - Simmering.
    - Giant.
  - Oven.
  - Broiler.

Circulating Water Heaters, being that class of heaters

ordinarily termed independent heaters and by preference designated a circulating heater by the nature of its operation, which is due to circulation produced by the action of the heater regardless of pressure conditions :

Direct Instantaneous Water Heaters, which is that class of heaters where the products of combustion come in direct contact with the water ; and the

Indirect Instantaneous heaters, being that class of heaters where the heat is transmitted through a metal wall, generally a tube, through which the water flows, and which are frequently controlled by an automatic valve, and are operated under service pressure conditions.

The Range Top Burners are usually of three sizes, which may be classed as :

Regular, being, as the name implies, the ordinary or medium size, of which there are usually three on a range ;

Simmering, the very small burner sometimes placed in conjunction with one of larger size, and intended to keep a vessel hot which has been brought to the desired temperature over a larger burner ; and the

Giant, being a burner of larger capacity than the regular, and intended for heavy or fast work.

The Range Oven is essentially an enclosed chamber, which may be evenly heated to any temperature required for domestic baking.

The Range Broiler, as usually constructed, is also an enclosed chamber, which is placed either below the oven or elsewhere, and while an even distribution of heat would be in no way objectionable, the fact that a very high temperature is required to do this work probably explains the reason for broiling being usually done on one side of a piece of meat at a time, it being possible in this way to get good results with simpler mechanical construction than where all sides are cooked at once.

Circulating Water Heaters.

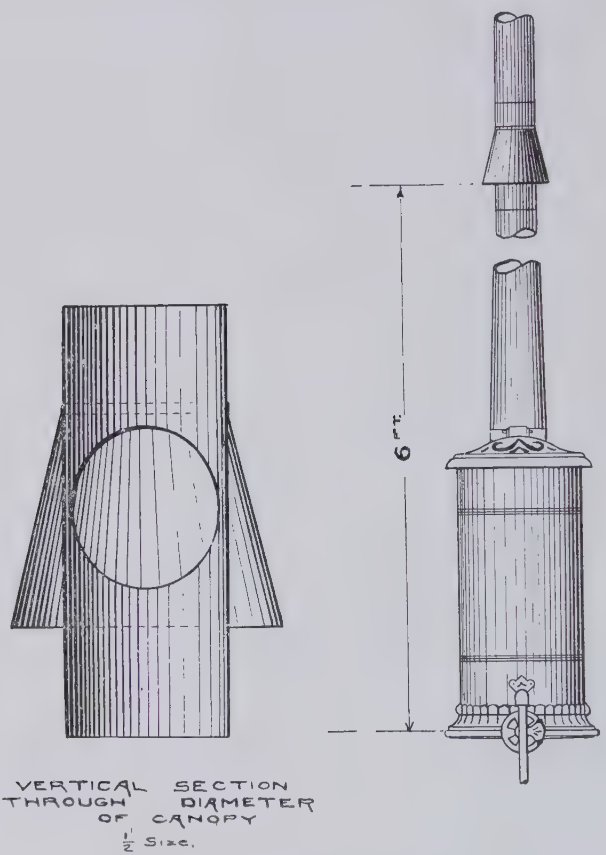
The circulating water heater, barring the direct instantaneous water heater, is the most efficient gas appliance now available, and yet its efficiency can be materially improved. The

efficiency of a circulating water heater will vary with the rate of circulation through it, and it is, therefore, important that for highest efficiency freedom of circulation should be considered. The reason for the higher efficiency of a circulating water heater having the freest possible circulation is due to the fact that a greater differential temperature is maintained between the products of combustion and the water being heated. The general rule is to consider that the amount of heat absorbed per unit of heating surface is exactly proportional to this difference in temperature. If a free circulation is secured, the rise in temperature of the water passing through the heater will be, perhaps, not to exceed 20 degrees, and it is also apparent that the less the rise in temperature the less will be the heat lost by radiation while the water is being transferred through the connecting pipe to the boiler and after it is in the boiler. It is possible to have this circulation so free that the rise in temperature of the water passing through the heater will not be sufficient for the purpose for which it is to be used, and some manufacturers have purposely congested the circulation of the water in their heaters so that a much smaller quantity of water is secured, but at a higher temperature. It is easily possible to congest the circulation in those heaters yielding free circulation, but not possible to give free circulation to those heaters offering considerable obstruction to the passage of water. We, therefore, think that manufacturers should design their heaters for free circulation.

Another consideration is this: Free circulation will be apt to materially increase the life of a heater where water is used containing considerable solid matter. The bulk of this solid matter is not deposited as a rule until the temperature approaches the boiling point, and again, if the circulation is free and rapid this deposition of solid matter, even though it occurs, will be carried over and the deposit will occur in the bottom of the boiler where it will not obstruct the passage of heat to the water and not curtail the efficiency of the heater by aging, as is now evidenced by some of the water heaters in every day use.

Although out of place in a report of this sort, it is well to call attention to the fact that the gas manager desiring to

secure economical results in the use of domestic water heaters may find it to his advantage to recommend the use of a supplemental boiler into which the water from the street mains



METHOD OF CONNECTING
CANOPY TO HEATER

Fig. 2.

will first flow and will be given an opportunity to take the temperature of the room before flowing to the heater. The highest efficiency heaters now on the market give a rise in temperature of from 30 to 40 degrees in the water passing

through the heater. This rise is often insufficient and requires that the heater be operated for a sufficient length of time to enable the entire contents of the boiler to be passed through the heater a second time.

The losses prevalent in present water heaters are due to over-ventilation and excessive flue temperature, and it is upon these two points that the manufacturers of the best appliances have made the most important improvement over others. Your committee advises against ever connecting these heaters to a flue, except that a broken flue pipe be used, such as is designated in Fig. 2, and we recommend that this canopy be placed at approximately six feet above the burner regardless of the length of the heater. Lack of draft in the chimney without the use of this canopy may cause the heater to smother, and excessive draft will draw in an immense quantity of air, far beyond the amount needed for proper combustion, and this excess air will rob the water of a considerable quantity of heat which it would otherwise secure.

Then there is one point which the manufacturers of gas water heaters have avoided, and though it is not probable that they have overlooked this possibility, they have not, to our knowledge, secured the result. As you all know, manufactured gas contains a considerable quantity of hydrogen. During combustion this hydrogen combines with oxygen to form H_2O. The heat of combustion of hydrogen is greater than that of any other gas, but unless each pound of H_2O which is formed is condensed before leaving the apparatus, it will carry with it at least 965 British Thermal Units of heat. If this moisture or steam were condensed within the apparatus and the water of condensation removed without its being allowed to fall back upon the heated metal of the interior (in which case it would be re-evaporated), this latent heat might be saved. The flue gases will of course pass off saturated but at a temperature of say 180 degrees, they would contain about 2% of moisture by weight, while at 212 degrees the amount of vapor carried off might be infinite. Usually there would be a pound of water formed by each 15 to 20 feet of gas consumed, or approximately an ounce of water to a foot of gas, while with no over-ventilation and a flue temperature

of 180 degrees only about .0003 pounds of water vapor would be carried off for each foot of gas burned. Thus it is evident that practically the total latent heat of water vapor might be saved. Besides the economy, which would be about 60 heat units saved for each foot of gas consumed, all objectionable

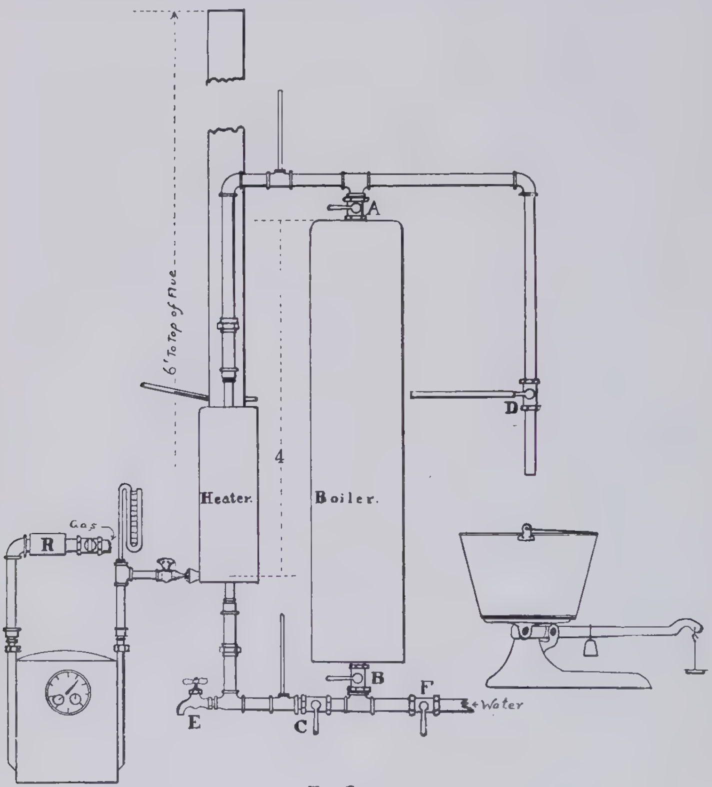


Fig. 3

METHOD of TESTING
CIRCULATING HEATER.

moisture would be removed from the room and flue, and as the formation of moisture is one of the most objectionable features of water heaters, this would be a very desirable improvement. Summed up, it would seem that the ideal water heater, in which perfect combustion took place with little over-ventilation

and from which the products of combustion were expelled at a temperature somewhat below the boiling point of water, would require no flue, for these water heaters are usually placed in large and well-ventilated rooms, and as there would be in this case neither moisture nor odor, a small amount of carbonic acid gas would not be a serious objection in the room.

Method of Testing Circulating Water Heaters.

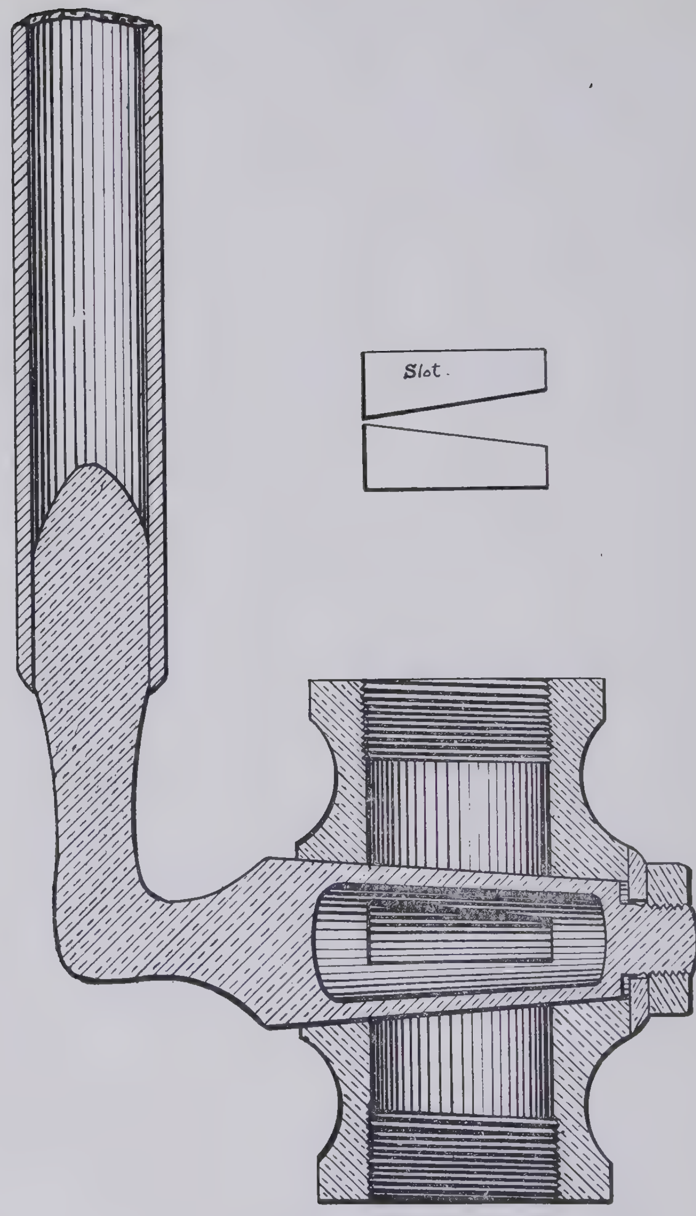
The heater to be tested is connected with a thirty gallon boiler, as shown in Fig. 3, with one inch pipe, a thermometer being placed in the horizontal pipes at the top and bottom, and valves A and B, in each of the vertical sections close to the boiler and a valve C, in the lower horizontal pipe. The heater is set so that the burner is four feet below the top of the boiler and a flue used extending six feet above the burner.

The water supply, which must have constant head, is connected in line with the lower horizontal pipe to the heater, as shown, and should have a cock F in it by which the whole system may be shut off. A bib cock E is placed on a tee at the junction of the lower horizontal pipe and the riser to the heater, by which the whole system may be drained, or by closing the cock C in the lower horizontal pipe, the heater may be drained when a change is made.

The outlet pipe is connected in line with the upper horizontal pipe and then brought down to such a height that the overflow may be conveniently caught in a bucket placed upon scales.

At the lower end of the overflow pipe is a special cock D, capable of accurate adjustment, by which the flow of water may be regulated.

This cock which is illustrated in section in Fig. 4, is an ordinary lever cock with the slots filed diagonally, as shown, so that a very gradual closing or opening may be obtained with the assistance of eighteen inches of gas pipe, which is driven on to the lever after it has been filed to an approximate fit.



OVERFLOW COCK

Fig. 4

The gas is measured by a test meter, and a good regulator R is placed back of it to assure constant pressure.

The first test of a heater is to determine the efficiency by natural circulation; this is done by lighting the heater, using the maximum flow of gas, and noting the differential temperature of the thermometers at the end of ten minutes. The overflow valve D only being closed during this test, valve F, must be open.

Then open the overflow valve D and cut the boiler out by closing the valves A and D at the top and bottom of it. Adjust the flow of water by valve D to such rate that the same difference of temperature is obtained that was observed at the end of the ten minute run.

When this temperature is obtained and has been maintained long enough to show that stationary conditions have been established, weigh off a quantity, say twenty pounds of water, observing the amount of gas used during this time.

The weight of this water times its rise in temperature will give the British Thermal Units collected, and this product divided by the total B. T. U.'s in the gas measured will give the efficiency of the heater in per cent. under usual working conditions.

As no two makes of heaters are built to use exactly the same amount of gas, it is desirable to have a test by which they may be compared, and this is obtained as follows:

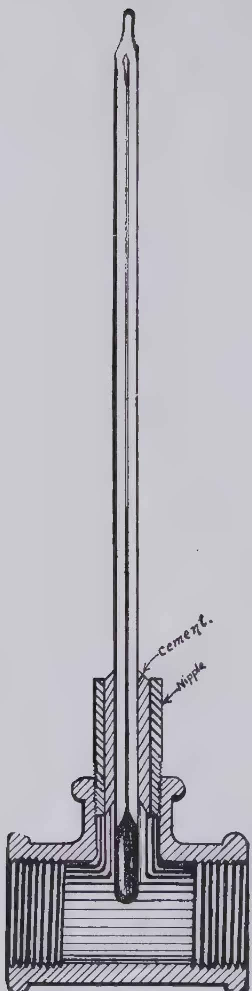
The heater, as above, is allowed the maximum supply of gas, but the differential temperature is adjusted to fifty degrees by the rate of flow of the water, and the efficiency determined as before.

Tests are made for each multiple of five feet of gas per hour, from the maximum down to ten feet.

By plotting curves of the results as found, an accurate comparison of efficiency and capacity may be obtained. Figure 6 shows how this may be done.

If the actual calorific value of the gas is not known, and cannot readily be determined, an arbitrary value may be assumed, and the results will then be comparative only; but a comparison is all that is necessary for the buyer.

Artificial gas will usually give about 650 B. T. U.'s per



METHOD of INSERTING
THERMOMETER.
Fig. 5.

foot, and this figure may be generally used where the exact calorific value is not known and great accuracy is not required.

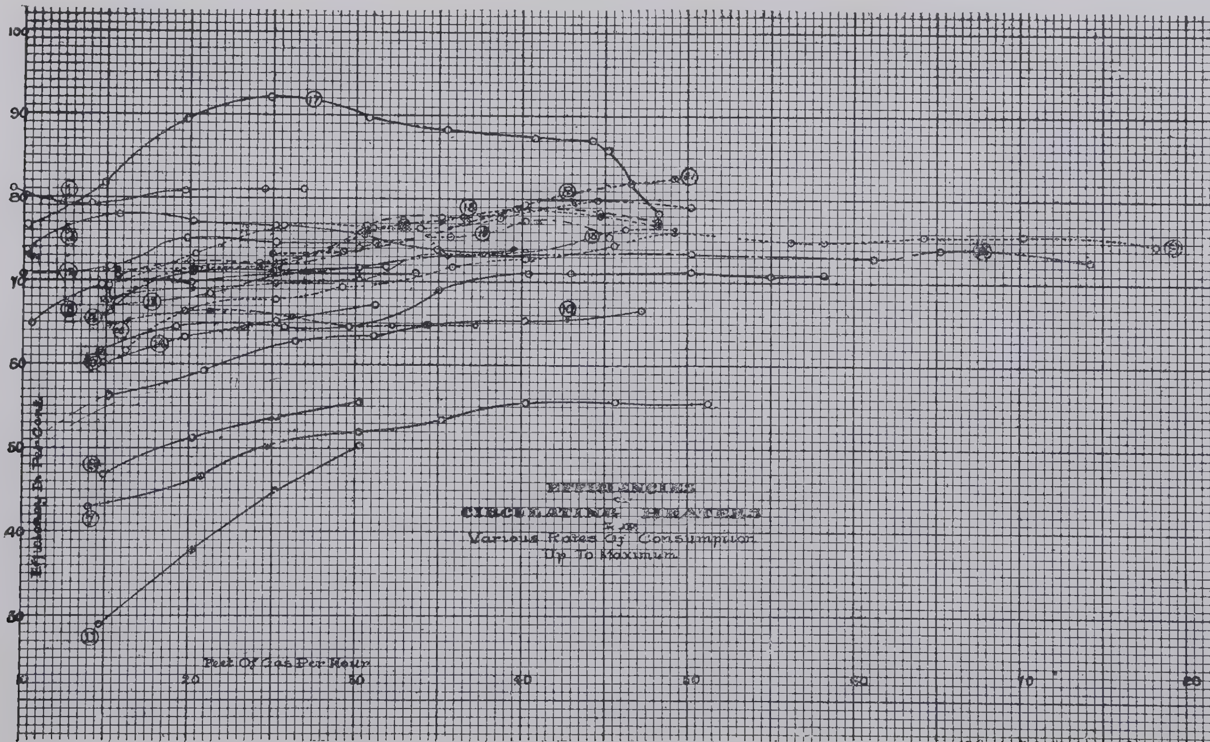

Efficiency In Per Cent.
Feet Of Gas Per Hour
EFFICIENCIES
CIRCULATING HEATERS
Various Rates Of Consumption
Up To Maximum

Fig. 6.

Aging Test.

Another valuable test to make on circulating water heaters is to connect them to a tank or tanks, from which the water is withdrawn with sufficient rapidity to prevent overheating in the same manner as in domestic use.

Then run them several hours each day—all alike—and make monthly determinations of their efficiency.

It will be found that some heaters stop up much sooner than others, and in some localities where considerable precipitate is formed, it may be impossible to use certain heaters even though their efficiency is very high when new.

Instantaneous Water Heaters.

The Direct Instantaneous Water Heaters, or those in which the products of combustion come in direct contact with the water, must necessarily be operated without back pressure.

This class has the great advantage of a very low thermal capacity, of condensing much of the water vapor formed by combustion, where water somewhat below the boiling point is being withdrawn, making it possible to obtain much higher efficiency than by the indirect method and for the same capacity, less size and cost than for the indirect heaters.

While again there are several disadvantages; the heater must be placed near the point where the water is to be used, it being necessary to regulate the supply at the heater, this is sometimes prohibitive, and if very hot water, that is, water near the boiling point, is required, there is an excessive loss in the flue, for as it is impossible for all the water to reach exactly the same temperature, when passing through the heater, the temperature of some will exceed the boiling point and, as it is not confined, will be lost up the flue as steam.

The Indirect Instantaneous Water Heater may have the advantage of being automatic, of being placed in any convenient location, regardless of where the water is to be used, and it may be adjusted so that water which is almost boiling, and in fact even steam may be obtained. Being under higher pressure, a high temperature can be maintained without formation of steam. Under an absolute pressure of 14.7

pounds, the formation of steam takes place at a temperature of 212 degrees; if this pressure is increased the boiling point is raised, which makes it evident that where an indirect heater is used under say 60 pounds gauge pressure, or 74.7 pounds absolute pressure, the boiling point is 307 degrees, so that the

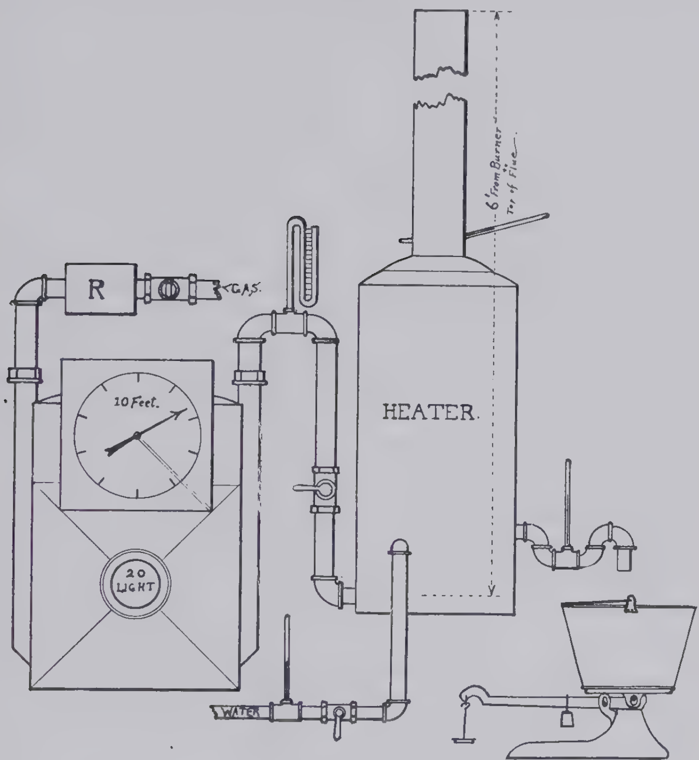


Fig. 7.

METHOD of TESTING
INSTANTANEOUS HEATER.

temperature of the water in the heater may be raised above the atmospheric boiling point without the formation of steam on the interior of the heater.

It is apparent that each heater has its advantages, and both classes give excellent results where properly applied.

Where very hot water is required, or where it is inconvenient to have the heater at the place where the hot water is used, or where hot water is wanted at several places, the indirect heater is superior.

But, if water somewhat below the boiling point is to be used, such as for the bath, or washing, etc., much higher efficiency may be expected from the direct heater, with less space occupied and less cost of installation.

Both have the very serious disadvantage of an excessive gas demand, which may necessitate the installation of an abnormally large service and meter for the consumer whose monthly bills are below normal.

Method of Testing Instantaneous Water Heaters.

This method is similar in principle to the method of testing circulating heaters, the connections being made as shown in Fig. 7.

As some of these heaters are designed for large gas consumption, a service, meter and regulator of ample capacity must be used.

A twenty light meter tested for accuracy may be arranged as shown in the figure, with a large dial calibrated to tenths of a foot, and with the hand attached to the spindle of the ten foot hand on the original meter dial.

A rubber band placed loosely over the spindle and one corner of the large dial, as shown, will take up the back lash of the train of gears in the meter, making it possible to estimate readings to hundredths of a foot.

The water supply is the same as for the circulating heaters.

A thermometer is placed in the water supply pipe near the heater, and a special cock, such as that shown for circulating heaters, is used to control the rate of flow, unless a good valve is supplied by the maker attached to the heater.

Another thermometer is placed in the outlet pipe, trapped as shown in the figure, and the water caught as before and weighed.

Those heaters having automatic controlling devices should have them cut out or removed during the tests.

A flue is supplied, the top of which is six feet above the burner.

The first test is to determine the efficiency of the heater at maximum consumption of gas, and with the flow of water adjusted so that a fifty degree rise in temperature is obtained.

A similar test is then made for each multiple of five feet gas consumption down to twenty feet, with a fifty degree rise in the temperature of the water in each case.

Then with the same rates of gas consumption as before, a similar set of tests is made, except that the water is drawn off at a temperature of 120 degrees in each case.

By plotting curves of the results obtained from each test, it will be readily apparent, when the requirements of a particular case are known, which heater should be supplied.

Discussion of Gas Ranges.

The very large number of gas ranges which are at present in use is sufficient indication that they have generally met with public approval, and there is no doubt that, compared with other methods of cooking, the gas range has no rival. Nevertheless, every gas manager knows that gas is not the most economical fuel, and this is the only reason for the gas range not being adopted by every individual situated where gas can be obtained. This being the case, it would seem entirely to the gas companies' interests to make a gas range as economical as possible. There is no doubt that where any gas apparatus is used for a variety of purposes, it is difficult to obtain high efficiency for each purpose, and this is probably the reason for the low efficiency of a gas range. For instance, though we have three different sizes of burners on the top of a range, under no condition does their efficiency run much above 50%. If it were possible to permanently place standard vessels on the top of a gas range, much higher efficiency might be expected, for then the burners would be arranged to do specific work. While the top burners are arranged as

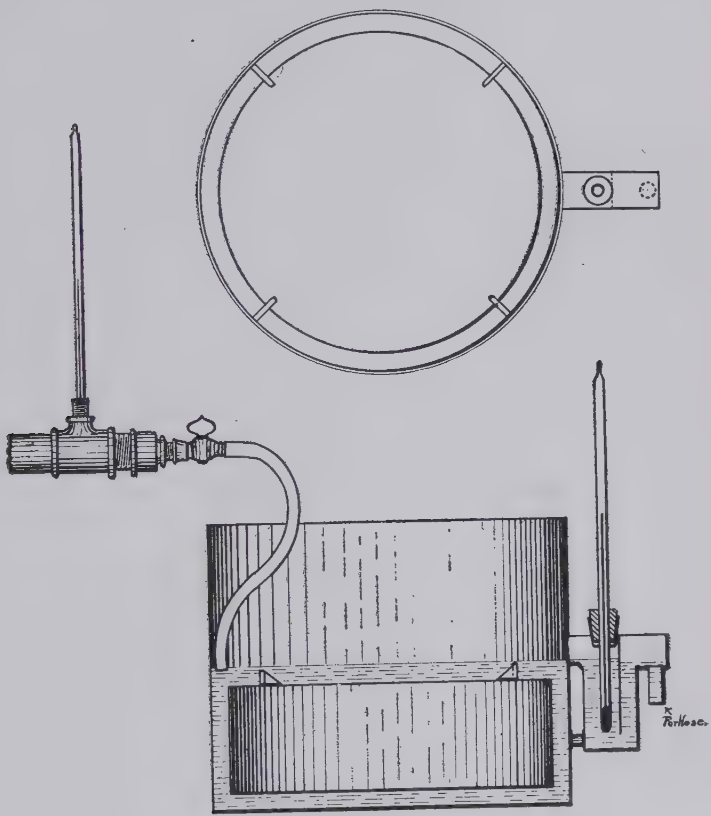
at present, the accompanying test will show their efficiency under good working conditions and is much to be preferred to either the test by evaporation, or by raising the temperature of a certain quantity of water a known amount in an ordinary vessel, as the condition established by this test may be maintained as long as necessary to check the results obtained.

The oven also is required to be used for numerous purposes, such as the baking of light cake, requiring a temperature of less than 300 degrees, or a batch of biscuit, requiring a temperature 100 degrees higher. Then also many people will use their ovens for roasting, though our modern cooks prefer to use the broiler, and of course where the ovens are used for this purpose a still higher temperature is at times desirable.

Owing to these various requirements, it would be difficult to make a standard apparatus for determining the actual efficiency of a gas oven. Consequently, in this case comparative tests which are very simple will be used, and as far as gas companies are concerned, quite sufficient. All the heat of the gas, when nothing is removed from the oven, must eventually pass out by the flue or by radiation. If each of these losses is determined, the manufacturer may readily find where an improvement is possible. The methods of determining the total flue loss and also that loss which is occasioned only by over-ventilation, that is, the heat which is carried out by the air passing through the oven which is not necessary to support combustion, are both described elsewhere.

To determine the relative value of insulating material used to prevent radiation, a very simple and effective method is to place, say 25 pounds of loosely coiled copper wire on the lower rack in the oven, then by lighting the oven burner bring the temperature somewhat above 600 degrees, then turn out the fire, close the flue and take successive readings of the temperature of the oven by a thermometer, the bulb of which is in the interior, and the graduations or stem outside the oven where it may be read. The curve of this fall in temperature, when compared with curves made under similar conditions, but in other ovens or with other insulating material, will readily show which is superior.

In making an oven, the object sought is an inclosed air space highly and evenly heated. It is apparent that a very thin wall of iron would not keep the temperature of the



APPLIANCE for TESTING TOP BURNERS.

Fig. 8.

inclosure as high as a heavy wall of non-conducting material with the same supply of heat, and if an excessively large flue with heavy draft were used, a lower temperature would be

obtained than with a flue of just sufficient size and with just the draft necessary to carry off the products of combustion.

Is there not room for improvement here?

The Broiler, the work of which can be duplicated in no other domestic appliance, is usually arranged in such a way that one is lead to suspect that the designers are not cooks.

How it was ever possible to induce a lady, and more than half the ranges are used by "the lady," to get down on all fours and watch a piece of meat broil is hard to understand.

But they do it, and they will continue to do it so long as those delicious steaks and chops cannot be duplicated in a more convenient manner. It is no wonder she has given the elevated broiler such a hearty welcome.

The side broiler has not been overlooked, but slight investigation will show that a majority of them go to houses where help does the cooking.

The work of the broiler, or some broilers, could hardly be improved, but the efficiency is very low, in fact, lower than any other part of the range. Again, there is evidently room for improvement.

Method of Testing Top Burners of A Range.

The top burners may be tested in two ways, the simplest and less accurate is to evaporate water over the burners.

On account of the variation of the boiling point, due to changes of atmospheric pressure, the impurities in the water, and the fact that much of the work of the top burners is bringing water to the boil, makes it a rather doubtful test of actual efficiency, and tests by this method are usually several per cent. below the results obtained by the following method, which we recommend.

Figure 8 shows a copper pan ten inches in diameter and eight inches high, containing a concentric pan which is three inches high, nine inches in diameter, hermetically closed top and bottom, and supported one-half inch from the bottom and sides of the larger pan by slender supports.

The purpose of the inner pan is to displace a quantity of water, and thus cut down the thermal capacity of the apparatus.

Four inches from the bottom of the outer pan is an overflow, arranged as shown, in such manner that the overflow water will have to pass through a U trap containing a thermometer before exit.

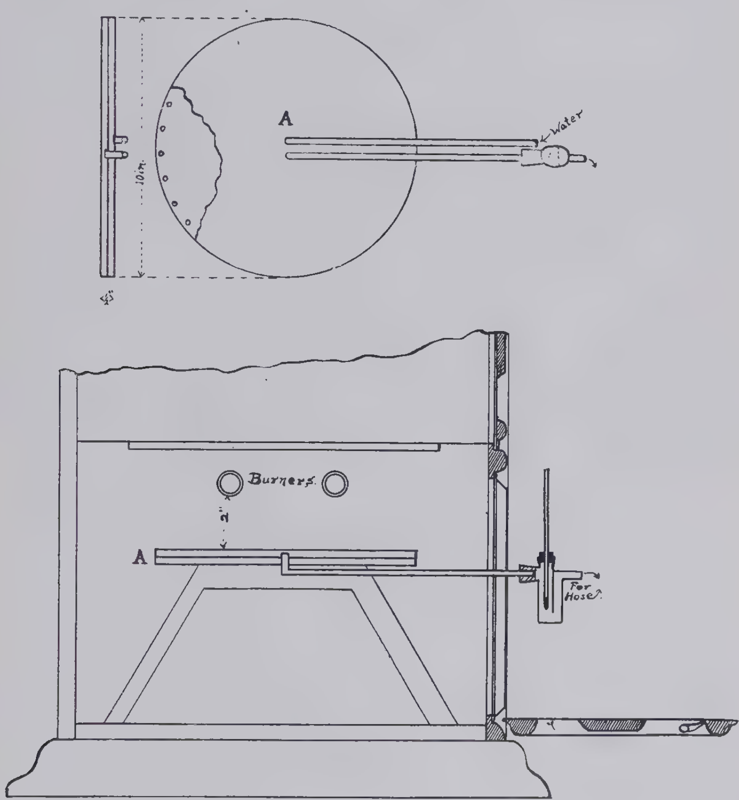
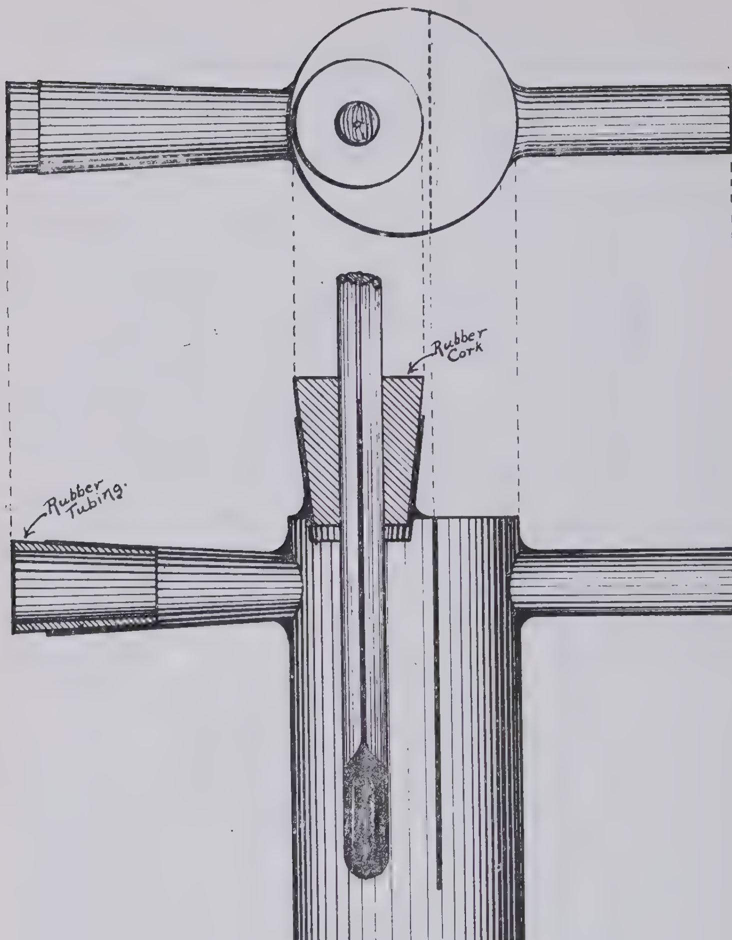


Fig. 8.

METHOD of TESTING
RANGE BROILER.

The overflow opening should be rectangular and one inch wide, and the opening for the hose connection should be about one-eighth inch lower, so that the level of the water in the pan will remain at practically four inches.



BROILER OVERFLOW.

Fig. 10.

The water is supplied from a constant head of known temperature, the manner shown being convenient, and the overflow is caught and weighed.

The test is made by allowing a small quantity of water to flow through the pan and the burner lighted at full consumption of gas under two inches pressure, then the flow of water is adjusted so that a fifty degree rise in temperature is obtained.

When conditions have become constant, a convenient quantity of water is weighed off, and the amount of gas used while the water is being collected is noted.

The heat units collected by the water divided by the total B. T. U.'s in the gas measured will give the efficiency of the burner under good working conditions.

Method of Testing Range Ovens.

To avoid complicated or troublesome methods necessary to determine actual efficiency, a deviation is here permitted, and comparison of the ovens only is made.

A stem thermometer, registering to 600 degrees Fahrenheit, is inserted through a hole in the top of the oven to as near the center as possible.

Asbestos paper may be put around the stem of the thermometer wet and then dried in any shape necessary to best support the thermometer.

Tests are made, starting with ten feet, for every multiple of five feet to the maximum flow, as follows:

The gas is adjusted to the desired rate of flow without being lighted; then shut off by another cock, there is always one back of the meter, so that the adjustment will not be changed and given time to clear from the appliance.

It is then lighted and readings of temperature taken each minute to get the curve of rise until the maximum temperature is reached.

A comparison of the results obtained from each oven will readily show which is superior.

If it is desirable to know the flue loss, see the article on that subject.

Method of Testing Range Broilers.

The efficiency of a Range Broiler is determined by the apparatus illustrated in Figure 9.

It consists of a flat closed copper pan ten inches in diameter, one inch thick, closed tight top and bottom, and with a parting diaphragm of copper half way between the heads, with small perforations near its periphery.

The water is supplied from a constant head of known temperature through a one-quarter inch brass tube to near the center of the lower chamber, it will spread passing to the upper chamber through the holes near the circumference of the parting diaphragm and then to the center of the upper chamber, from which it is drawn down and out by another quarter inch tube extending up from below through the lower chamber and almost touching the upper cover.

A slight pressure of water on the inside of the pan will raise the upper cover in the center sufficiently to allow the necessary amount of water to pass out, and the slight rise in the center will cause the water, from all sides, to flow into the center, provided it is placed perfectly level.

The top of the pan should be just two inches below the bottom of the flame, and must be central, otherwise, in the broiler.

The upper side of the pan must be a dead black, readily obtained with a coat of lamp black mixed with spirits of turpentine, and laid on evenly.

The door of the broiler is left open and a door of sheet iron made to fit in its place, as shown. This door must give the same insulation and ventilation which the original door had.

The water supply and return are brought through this door and its temperature determined at both these places.

The appliance for determining the temperature of the broiler overflow is shown in Figure 10, while the supply may be the same as for the top burner test and the temperature obtained in the same way as shown in the illustration of the appliance for testing top burners.

Flue Loss.

There is a great difference in the amount of heat lost in the flues of different appliances. The loss in water heaters being very much less than that of a range, but there is great over-ventilation in all.

The method of determining the total loss in the flue and the loss due to over-ventilation is each given, and it will certainly be found worth the while of any manufacturer to become familiar with them.

The gas company is not particularly interested in knowing where the losses occur in an appliance, they only wish to know which one gives the highest efficiency.

The Total Loss in the Flue.

The total loss in the flue consists of the heat carried off by the flue gases due to their increased temperature over that of the room and the service gas, and by the latent heat of the water vapor formed by the combustion of the hydrogen in the gas, and its rise in temperature.

The following method will show what per cent. of the total heat in the gas passes out of the flue:

METHOD OF DETERMINING THE TOTAL FLUE LOSS.

From an analysis of the service gas determine the total Hydrogen (H) and Carbon (C) in one foot of this gas by weight at 32 degrees and 30 inches.

Analyze the flue gas with an Orsat Apparatus, description of which follows, finding the per cent. by volume of Carbon-dioxide (CO_2), Oxygen (O) and Nitrogen (N) contained in it.

Then assume a sample of one hundred cubic feet of this flue gas.

Multiply the per cent. of CO_2 in the flue gas, which may now be called feet, by .12267, which is its weight per cubic foot under the assumed conditions of 32 degrees Fahrenheit and 30 inches barometric pressure. Then three elevenths of this product will be the weight of C in the assumed sample.

This weight of C just found divided by the weigh of C in one foot of the service gas will give the number of feet of service gas proportional to the flue gas sample.

Having now a known number of feet of service gas, this quantity divided by the weight of H in one foot of service gas will give the weight of the H in the flue gas sample of 100 cubic feet.

Nine times this weight of H just found will give the weight of water (H_2O) vapor which passed the flue during the sample.

The weight of H_2O vapor times its specific heat, which is .48 approximately, times the difference in temperature between the flue and the boiling point of water at the particular location where the test is made. (Sea level 212 degrees, Denver 202 degrees.)

Plus the weight of H_2O vapor times the latent heat of water for the barometric pressure of that location. This latent heat for sea level is 965.7 while for Denver it is 972.9, which shows the possible variation.

(The table on page 663 of Kent's Engineers' Pocket Book will give the required data.)

Plus the weight of H_2O vapor times the difference in temperature between the room and the boiling point of water (times the specific heat of water which is one) will give the total British Thermal Units of heat lost in the water vapor, or steam.

The CO_2 found by the Orsat, times the weight of one cubic foot, as before, .12267, times its specific heat, which is .217, times the difference in temperature between the room and the flue will give the heat carried off by this gas.

The O and the N are then treated in the same way, the O times .08921, times .21751, (its specific heat,) times the difference in temperature between the room and flue and the N times .07831, times .2438, (its specific heat,) times the same difference of temperature.

The sum of the heat lost by the H_2O vapor the CO_2 the O and the N will give the total B.T.U.'s carried off by the flue gases.

And the B.T.U.'s lost in the flue gases divided by the total B.T.U's in the service gas proportional to the sample as found in paragraph five, will give the percentage of heat lost in the flue.

FORMULAE FOR DETERMINING THE TOTAL FLUE LOSS.

Let H = Wt. of H. in one foot of service gas.
Let C = Wt. of C. in one foot of service gas.
Let CO_2 = Per cent. by volume of CO_2 in flue gas analysis.
Let O = Per cent. by volume of O in flue gas analysis.
Let N = Per cent. by volume of N in flue gas analysis.
Let t = Temperature of the room.
Let t' = Temperature of the flue.
Let T = Temperature at which water boils at that location.
Let L = Latent heat of vaporization of water at that location.
Let V = Calorific value of one foot of service gas at 32° 30″.

$$\frac{\dfrac{[.1445292(t'-T)+.301104L+301104(T-t)]CO_2}{\dfrac{C}{H}}+(.026619\ CO_2+.0194\ O+.01909N)(t'-t)}{\dfrac{.033456\quad CO_2V}{\dfrac{C'}{H}}}$$

= per cent of total heat in the gas, which is lost in the flue.

Flue Loss Due to Over-Ventilation.

In every gas appliance a certain amount of air must be admitted to support combustion, and further, in every case there is more air admitted than is theoretically necessary for this purpose.

This air enters at the temperature of the room, and leaves at the much higher temperature of the flue.

Suppose a case of 200 rise, which is common, and every pound of air will carry off about 47½ British Thermal Units of heat.

This is the loss due to over-ventilation, and the object is to determine what proportion this is of the total heat, which the gas was capable of developing.

To make this determination it is necessary to know what proportion the service gas was to the sample of flue gas. That is, how much service gas was burned during the passage of a given sample of flue gas, and an analysis will not show this.

A simple way of making this determination is illustrated in Figure 11, entitled "Test for CO_2."

The apparatus consists of a test meter, a Welsbach lamp without a mantel, and a gasometer of several cubic feet capacity.

The gas is measured by the meter and burned in the lamp, the products of combustion being conveyed into the gasometer by suction through a pipe making close connection by a tin cone or funnel with the chimney of the lamp.

A suction of about three inches is produced in the gasometer by balance weights, and is then controlled by a cock in the flue pipe so that a natural flame is produced.

The exact capacity of the gasometer should be determined by filling it with air drawn through the meter in the same way the flue gas is taken in, and with the same suction to start and stop with that is used in the experiment. One and a half or two inches will be found convenient.

The gasometer being filled with flue gas, or products of combustion, and its total capacity or cubical contents known, an analysis by an Orsat is made of a sample of the contents and the percentage of carbondioxide determined, and from this is computed the total volume of CO_2 in the gasometer.

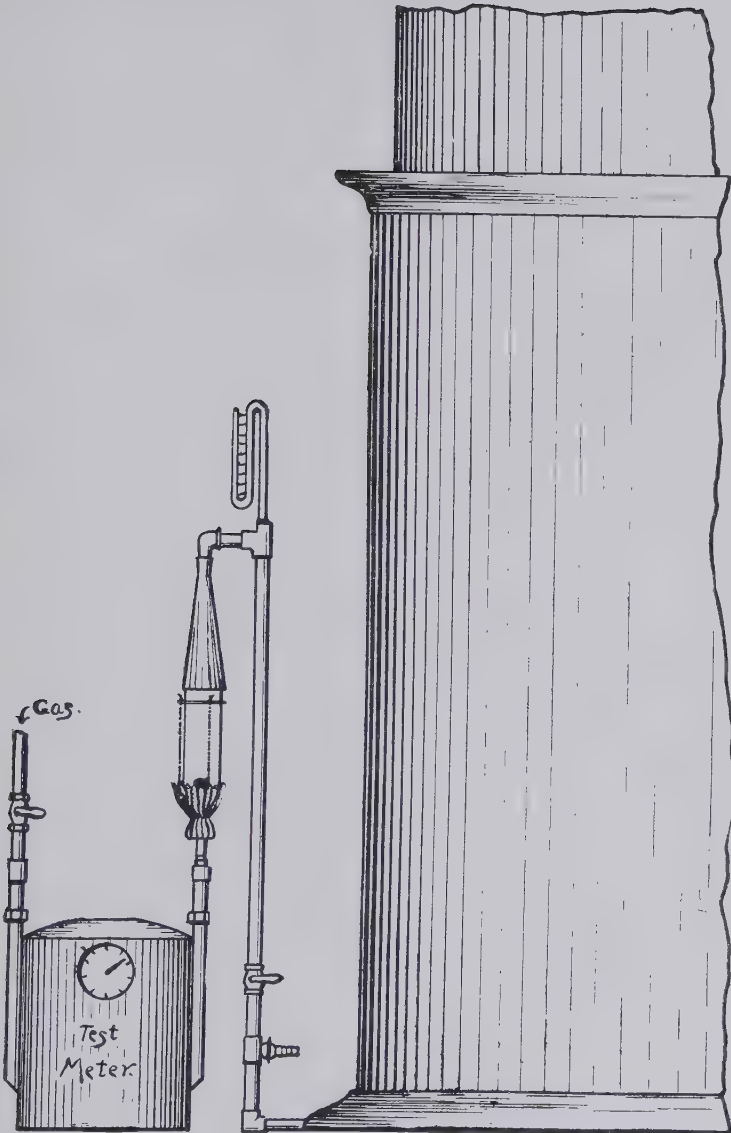
The meter will show the amount of gas used to make this quantity of CO_2, from which the amount of CO_2 formed by the combustion of one foot of service gas may be determined. Or this can be computed from an analysis of the service gas, but is not apt to be so accurate.

This quantity will not usually vary materially from day to day, so that if accurate results are once obtained, they may be used until some change occurs in the service gas.

The over-ventilation loss may now be found.

With an Orsat apparatus the per cent. of carbondioxide and oxygen in the flue gases are determined, then for convenience assume these figures to be cubic feet.

The CO_2 is then divided by the amount of CO_2 found by the experiment to be formed by the combustion of one foot of service gas, which will give the number of feet of service gas proportional to a sample of 100 cubic feet of the flue gas, and this quantity multiplied by the calorific value of the service



TEST for CO_2.

Fig. 11.

gas will give the total heat supplied during the passage of such a sample.

The oxygen found by the analysis is then multiplied by .0926 a constant, and by the difference in temperature between the room and the flue, which will give the total heat carried off by the excess air.

The heat lost divided by the total heat supplied will give the per cent. of loss due to over-ventilation.

To Determine Per Cent. of Over-Ventilation.

Loss not being considered the per cent. of over-ventilation may be determined as follows:

Make a flue gas analysis by volume with an Orsat for CO_2, O and by deduction N.

In the proportion N : O :: 79.3 : 20.7. Substitute the per cent. of N. found by the analysis and solve for O.

From this value for O deduct the value for O as found by the analysis, which was the free or excess O, and the result will be the O used for combustion.

The free O divided by the O used will give the per cent. of over-ventilation.

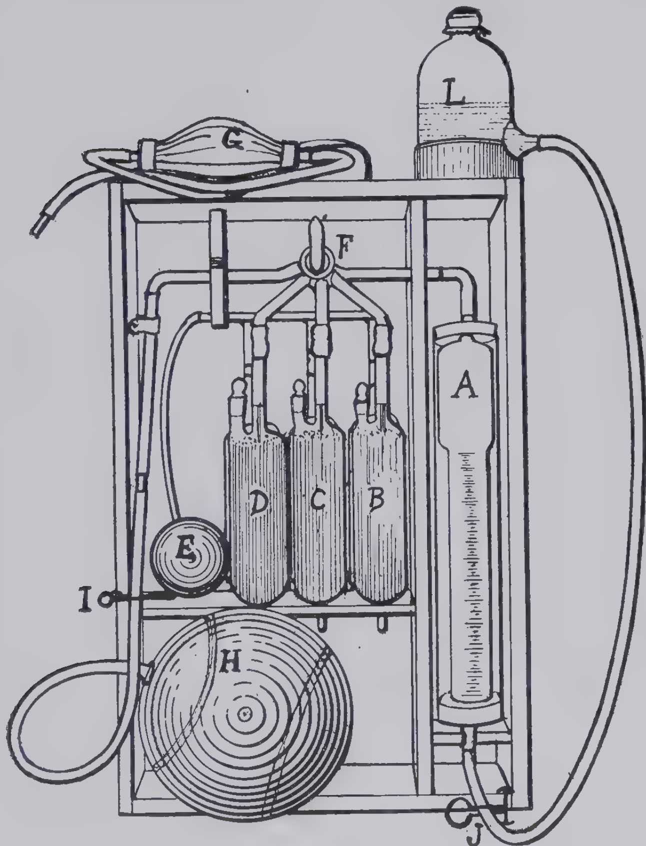
The Gas Analysis With Orsat Apparatus.

The products of combustion from gas appliances may be readily analyzed by means of an Orsat Apparatus, many modifications of which are on the market, a description of one type, however, will suffice.

The method is to take a sample of known volume and by bringing it successively in contact with absorbents of the different constituent gases, determine by the volume remaining how much was removed in each case, and consequently the per cent. by volume of the different gases.

The apparatus, illustrated in Figure 12, consists of a measuring burette A with a capacity of one hundred cubic centimeters, one end of which is contracted so that the graduations may be separated sufficiently to be legible to tenths of cubic cm., the whole scale extending through about 35 C. C.

The burette is water jacketed so that the gas sample will readily reach the temperature of the room.



ORSAT APPARATUS

Fig. 12.

A rubber hose makes connection between a leveling bottle L of about 200 c. c. capacity, and with a low side hose connection as shown, and the lower end of the burette.

This bottle is about three-fourths filled with water containing some salt, and by raising or lowering it, gas is forced from or drawn into the burette by the water.

The reagents are contained in three double bulbs, B, C and D, the bottoms of which connect with similar bulbs directly behind them. The top ends of the front bulbs connect by capillary glass tubes and a five way cock with the burette, and another tube is arranged by which the sample of gas may be drawn in or expelled.

The top ends of the back bulbs connect with a small bag E which at first is filled with air. The object is to use the same air to fill the back bulbs each time the reagents are drawn into the front bulbs; in this way the oxygen is soon removed from the small bag leaving only nitrogen, a neutral gas, in contact with the absorbents, thus prolonging their life. For collecting the gas sample, an aspirator G and a rubber bag H, with a short length of hose attached, are convenient.

The sample of gas is taken from near the center of the flue and close to the appliance, to avoid errors from infiltration of air at the joints, and is forced into the sample bag by means of the aspirator, a pinch cock I being used to retain the gas.

The bag should be deflated by rolling it up, and again inflated several times before a sample is retained to insure one free from the former contents of the bag.

The best means of procuring the flue gas sample, is to use two gas pillars, with the lava tips removed, one placed inside and the other outside the flue pipe, a close nipple connecting them through a well fitting hole in the pipe, so that they clamp it tightly.

The absorbing reagents are as follows:

For carbondioxide, Bulb B—A 16 per cent. solution of caustic potash (KOH) made by dissolving 16 grams in 84 c. c. of distilled water.

For oxygen, Bulb C—An alkaline solution of pyrogallic acid ($C_6H_3(OH)_3$). Dissolve 20 grams of pyrogallic acid in 100 c. c. of water. When about to use mix some of this solution with its own volume of the potash solution.

For carbonmonoxide, Bulb D—A strongly acid solution of cuprous chloride. Dissolve 15 grams of the red oxide of

copper (CU_2O) in 100 c. c. of strong hydrochloric acid, specific gravity 1.19. Keep this solution in a glass stoppered bottle with scraps of metallic copper, and keep pieces of clean copper wire in the absorption bulb with it.

The reagents are applied in the order given, the analysis being conducted as follows :

The reagents are drawn up to the marks on the capillary tubes above the bulbs, then all the air is expelled from the burette by raising the leveling bottle, and filling the water to the mark on the capillary above it.

Then the sample bag is attached and the burette filled with gas by lowering the bottle L.

This sample is expelled, the bag being disconnected, as it contains the former contents of the long capillary tube and connections, and a new sample is drawn into the burette, filling it to about half an inch below the zero on the scale. The cock F is then closed and the sample allowed to reach the temperature of the burette, which is, of course, the same as the room.

Then set the leveling bottle on top of the case as shown, and pinch the cock J sufficiently to compress the gas in the burette slightly, then open the cock F to the air and carefully admit enough more water, by means of the pinch cock J, to raise its level exactly to zero, then at once close F, when the burette will contain exactly 100 c. c. of the flue gas at atmospheric pressure and the temperature of the room, so that any change of volume may be assumed to be caused by the action of the reagents.

The five way cock, F, is then turned to the KOH bulb B and all the gas forced into it by raising the leveling bottle, being careful that no water follows the gas over.

Then after a few minutes, lower the bottle and draw the gas back until the KOH reaches the mark on the capillary.

Repeat this two or three times and then take a reading with the leveling bottle held so that the water level in it is the same as in the burette with the pinch cock J open and F closed.

Force the gas once more into B and let it stand, then bring it back and if the reading is the same as at first observed, say

10, it indicates that 10 c. c. of CO_2 were absorbed and therefore the sample contained 10 per cent of CO_2.

If the reading differed from the first, repeat until the readings become constant.

Then the remainder of the gas is forced into bulbs C and D successively in exactly the same manner, except that as O and CO are more difficult of absorption than CO_2, more time must be allowed the gas in contact with the absorbents.

After bringing the gas out of the cuprous chloride solution bulb D, always pass it once or twice into the KOH bulb B before taking a reading to remove gas evolved there.

If we obtain readings of 7, 15, 19 successively, it indicates that the sample of gas contained 7 per cent. CO_2, 15—7 = 8 per cent. O, 19—15 = 4 per cent. CO. The rest is nitrogen, 100—19 = 81 per cent. N.

These results are in per cent. by volume, and if the per cent. by weight is required, multiply the per cent. by volume of the constituent gases by their respective densities, and divide each product by the sum of all the products.

The densities may be taken as follows:

Air being	1
CO_2 is	1.520
CO "	.967
O "	1.105
N "	.970

THE PRESIDENT: Are the Editors of the Wrinkle Department ready to submit their report?

MR. BRYCE MCADAM: Mr. President, I desire to take this opportunity of thanking those who have contributed to the Wrinkle Department of the American Gas Institute and especially to those who have contributed so generously. It is hardly necessary for me to say more, from the fact that the wrinkles as published should speak for themselves and there are still a few in the hands of the editors unpublished, which were received somewhat late.

Inasmuch as the time for getting together the wrinkles was very limited, it was impossible to devote the proper care in

doing the work. In fact so much so, that we had scarcely time enough to look over some of the contributions before sending them to print. I do not think it necessary to do any reading, as I presume you will all read them over for yourself.

On account of the hurry there may be some errors which have crept into the work and we ask you to kindly overlook these things under the present conditions.

THE PRESIDENT: Gentlemen, what is to be done with this report? I suggest that if they have any Wrinkles that are not included in the volume that they be submitted with it.

A MEMBER: Mr. President, I move that the Wrinkles be published as a whole, together with those which are not included in the pamphlet, and that the thanks of the Institute be given to the Editors for their work.

Motion seconded.

THE PRESIDENT: Gentlemen, all in favor of the motion will signify by saying "Aye." Contrary minds, "No." It is a vote.

WRINKLE DEPARTMENT.

BRYCE MCADAM AND W. E. STEINWEDELL,
Joint Editors.

Scurfing Retorts—Mr. George S. Carson, Iowa City, Ia. Photograph shows a very simple and inexpensive method of taking carbon out of retorts by using a No. 1 Emerson pressure blower, located directly in front of the retort at a distance of about nine feet, to prevent the motor from getting too hot. By connecting this apparatus with a galvanized iron pipe to a three-inch cast iron pipe, which is laid in the bottom of the retort, extending about half way back, then by bricking the retort mouth two-thirds full, the carbon can be all burned out, as well as the stand-pipe thoroughly burned out, in from six to eight hours time. The power required is about one-sixth of a

horse power and the cost of operating nominal. The work, however, is thorough, with no damage to the retorts.

See Figure No. 1.

Inspecting Bench Heats—Mr. Henry Rochat, Indianapolis, Ind. We have taken the sight plugs of the stoppers out of the nostril holes and replaced the plugs with a piece of mica

Fig. 1.

and setting it in cement, making an air-tight joint. In taking great care in cutting the mica you can see your heats very nicely, and a good view of the interior of the bench and flues is obtained.

By making several observations of the color of the heats the foreman is enabled to detect any variation at once, as it is

customary for the foreman of each shift to make the rounds and observe the heats frequently. It is also convenient for the officials, when passing through the retort house, to make an examination with very little time.

Ventilating Retort House—St. Paul Gas Light Company, St. Paul, Minn. For ventilating the retort house, a line of galvanized iron pipe, six inches in diameter, is run along the wall opposite the benches, shoulder high from the floor.

Outlets are provided at suitable distances apart, so as to direct the fresh air out into the room, the air being supplied from a blower connected to the line of pipe outside.

This has been found very efficient in providing ventilation during the summer months, in addition to the ventilation for carrying off the smoke and fumes at the top of the house.

Each outlet has a shutoff valve, so that the currents of air can be easily controlled.

Chart for Charging Retorts—St. Paul Gas Light Company, St. Paul, Minn. This chart is framed in a conspicuous place in the retort house for showing the men the time of charging the retorts.

The frame has a protection from dust and dirt, and the chart can be easily removed when changes in the schedule are desired.

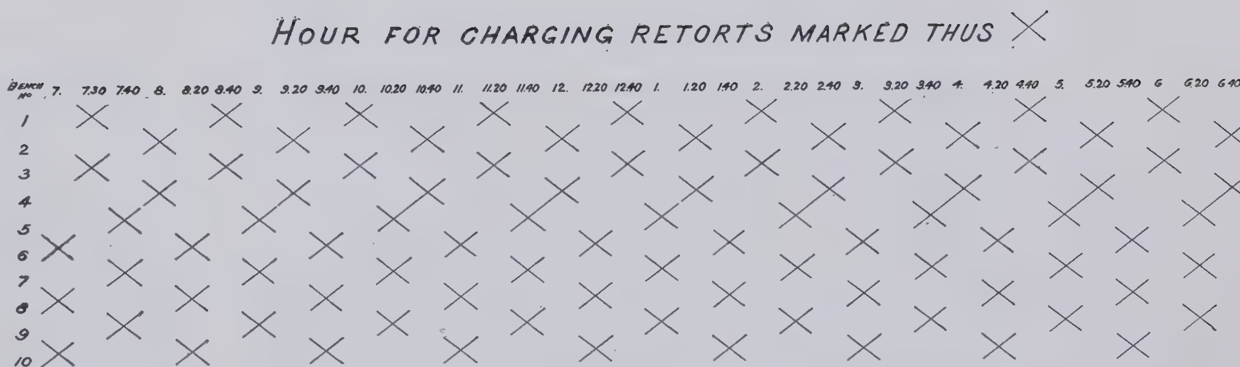
It is easily read, and is of assistance to the men in keeping track of their work in charging and drawing.

The figure shown is for ten benches of nines, running four-hour charges, three retorts being charged at a time.

See Figure No. 3.

Temperatures in Water Gas Operation—Mr. W. A. Baehr, St. Louis, Mo. At station "B," Laclede Gas Light Company, we have recently installed a pneumatic pyrometer with recording device, which we are using in a series of tests conducted with a view to learning more about the manufacture of water gas and the effects different temperatures and pressures have upon the quality and quantity of gas made.

The pneumatic pyrometer used is manufactured by the Uehling-Decker Company, Passaic, N. J., and depends for its action on the velocity at which air at different temperatures is


HOUR FOR CHARGING RETORTS MARKED THUS
BENCH No.
7. 7.30 7.40 8. 8.20 8.40 9. 9.20 9.40 10. 10.20 10.40 11. 11.20 11.40 12. 12.20 12.40 1. 1.20 1.40 2. 2.20 2.40 3. 3.20 3.40 4. 4.20 4.40 5. 5.20 5.40 6 6.20 6.40
1
2
3
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9
10

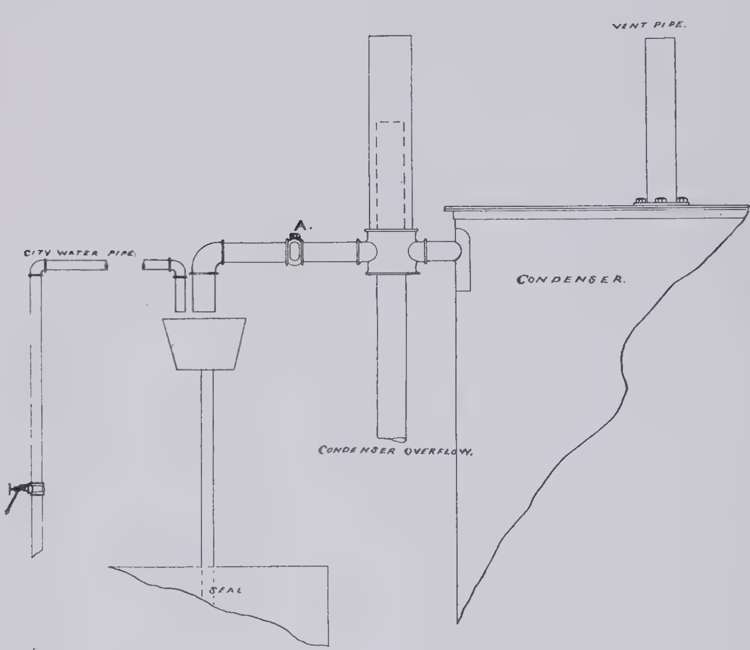
Fig. No. 3.

drawn through a small hole. A constant suction is produced by a steam jet, and the air, after being heated in the fire tube, is passed through a small opening, cooled and drawn by the steam suction jet through a second opening of the same size. A water column is so arranged that a direct reading of the temperatures is obtained by the relative velocity of the passage of the air through the two small openings. This pyrometer is arranged to register the temperatures at the top of the middle third of the fuel bed of the generator, and the attached recording gauge keeps a permanent record of the temperature, which varies from 2000° F. to 2500° F., but drops to about 1800° (degrees) before clinkering.

The temperatures at the bottom of the middle third of the fuel bed of the generator are indicated by an electric pyrometer, which indicates from 800 to 900 degrees Fahr. in ordinary operation. This instrument is manufactured by Charles Englehard, No. 41 Cortland street, New York. In this apparatus a platinum and iridium wire are fused together and inserted in a porcelain fire tube. The electrical current generated by the heat is indicated by the needle of a voltometer, which is so graduated that temperatures may be read direct. With these devices experiments are being carried on showing how the temperature varies for different lengths of blows and runs; or, vice versa, how the blows and runs must be varied to keep the temperatures within certain limits. At the same time a series of samples of blast gases and blue gas is taken at regular intervals, one sample being taken each minute during a blow and the following run. The analysis of the blue gas indicates the value of the gas made during each minute of the run, while the percentage of carbon dioxide and monoxide in the blast gas samples gives an idea of the efficiency of combustion during the blow. The amount of gas made during each minute of the run is determined by observations made on the relief holder.

In addition to investigating the effects different intervals of runs and blows have upon temperatures, tests are being made to ascertain the effects of different steam pressures upon temperatures and upon the amounts and qualities of gas produced. An idea of the efficiency of the set with steam at

different nozzle pressures and at different temperatures, is obtained by the methods outlined above. In this case, however, the experiments are carried further by passing a measured amount of gas through calcium chloride tubes, which absorb the undecomposed steam, and show the relation between the amount of steam actually used in the manufacture and the resulting quantity and quality at different pressures and temperatures.



ARRANGEMENT SHOWING SIGHT FEED WATER INTO SEAL POT FROM CONDENSER IN WATER GAS PLANT.

Fig. No. 6.

At present the experimental work is being confined to the generator, but after this has been thoroughly tested, we intend to follow it up by a similar investigation of the conditions which exist in the carburetter and superheater.

Supplying Hot Water to Seal of Water Gas Apparatus—Mr. Edmund Cathels, Providence, R. I. This arrangement

aims to reduce the variation of flow of water from condenser into seal pot to a minimum, at the same time allowing the supply of water to condenser to vary to a fairly considerable extent; the supply of water from condenser to seal pot, under this arrangement, is under a constant head, and once the stop-cock "A" is properly adjusted it never need be altered, the flow of water into the seal pot is always in full view of operator.

It is also advisable, however, and even necessary, for emergency, to have some other means of supplying water to seal pot, and a city water supply, or some other reliable supply, should be run with a quick opening valve located at a point convenient to operator.

See Figure No. 6.

Filter for Overflow of Water Gas Tar Separators—Mr. Edmund Cathels, Providence, R. I. A good and simple filter arrangement, following tar separators, is shown in sketch.

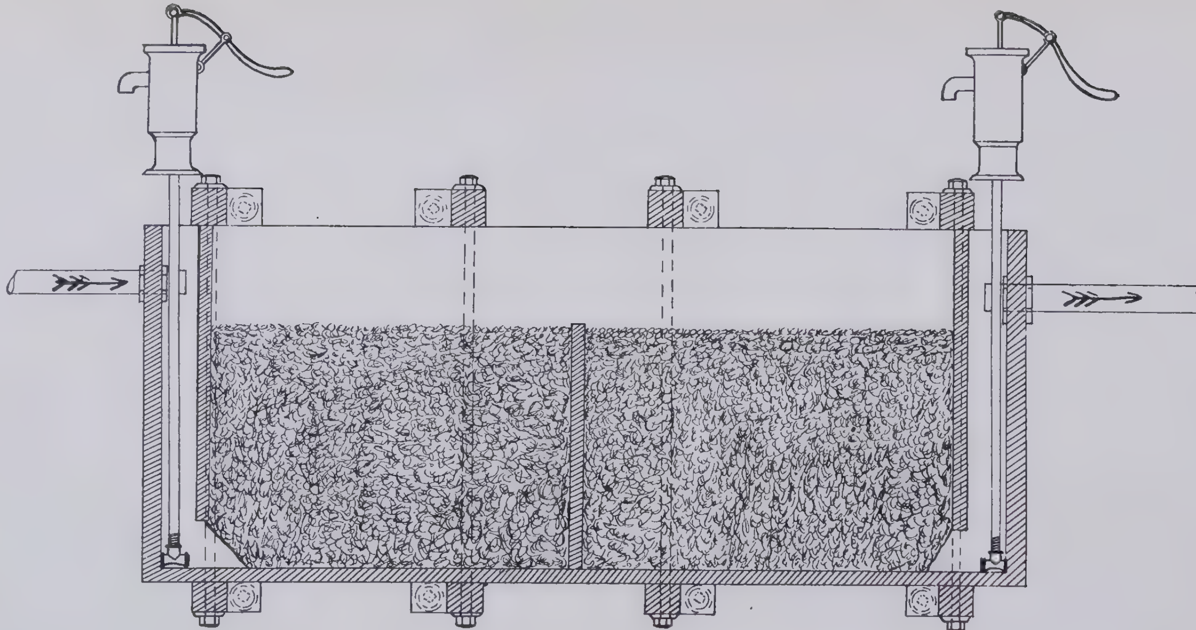
The pumps are used whenever it is desired to test the condition of filter, and also for the purpose of pumping any tar that may have carried over that far, thereby prolonging the life of material, and keeping same in good working condition.

Two filters as above shown each 4′-0″ wide x 4′-3″ x 15′-0″ long, each containing 220 cubic feet of coke, were in use for nearly seven months, without the need of changing coke, and in the time mentioned, passed an effluent from a water gas plant that made four hundred and fifty million cubic feet of gas, besides taking care of all drips around the plant, and drips on distributing system.

See Figure No. 7.

Tar Burner—Mr. G. I. Vincent, Des Moines, Ia. This burner, as shown in the cut, is made up of ordinary fittings and is constructed as follows:

A 1″ nipple is cut off square and a light cut taken out of the inside on the lathe. A ½″ coupling is then screwed on to a ½″ nipple and placed in the lathe and a light cut taken off the coupling so that it will make a forced fit inside of the



FILTER FOR EFFLUENT AFTER PASSING WATER

GAS TAR SEPARATORS.

Fig. No. 7.

1" nipple. The 1" nipple is then ground on with emery so that it makes a tight joint between the coupling and the nipple. The coupling is removed and two or more 5-32" holes are bored through the coupling for the tar and longitudinal slots for the steam are filed from one end of the coupling to the other so that the hole comes in the bottom of the slot. This is all the machine work required on the burner which is made up of fittings as shown.

In action the tar flows through the 45 degree ell and out the 5-32" holes. The steam flows into the 3-8" ell and out through the slots filed in the ½" coupling. The burner is

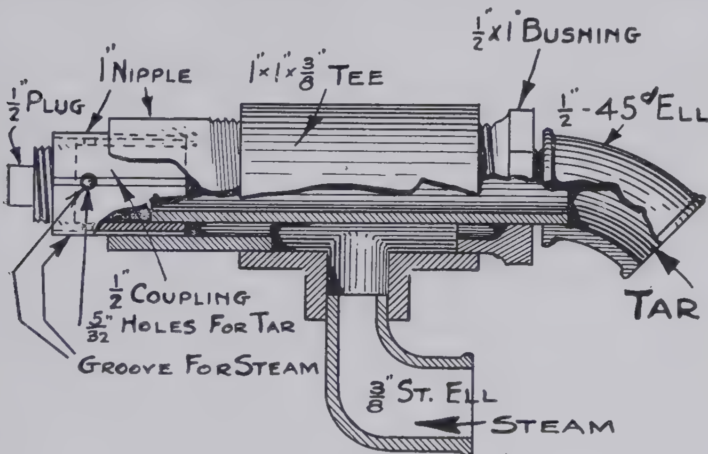


Fig. No. 8.

connected up in the usual way, the steam and tar connections running through a large hole cut in the front of the boiler just beneath the shell, and the burner is set pointing downward at an angle of 45 degrees or more. The best results are secured by removing the grates and excavating the ash pits to a depth of one or two feet and arranging a false grate of fire brick in the bottom of the excavation and also walling up the doors, leaving only such openings as are found by experiment to be necessary to admit the proper amount of air for complete combustion. If the burner stops up, due to improper screening of the tar, it can be easily cleaned by removing the ½" plug. See Figure No. 8.

Pressure Gauge—Mr. James H. Walker, Milwaukee, Wis. The sketch shows a home-made gas-pressure gauge for either foul or clean gases, but especially suited for the former, the entire absence of glass tubing making it substantial, and avoids the necessity of taking readings through a stained and dirty glass.

The syphon "A" is made of 1¼" iron pipe, fitted with draw-off cock "B" and filler "C," as shown. The scale case "D" is made of heavy tin, and slips over the cap "E." The scale "F" is made of paper or other material, and marked off in spaces as shown, each one-half inch representing one inch of pressure, and fastened in a suitable manner to the inside of the scale case.

Sketch "B" shows float and indicator "G," enlarged for convenience in illustration. The float "H" is made of tin, the stem "I" of No. 12 wire, the same passing through the conical shaped hole "J."

In case of a sudden rising of pressure the conical top of float "H" is thrown in contact with the counter-sink opening in cap, thus preventing overflow.

The principal advantages claimed for this wrinkle is cheapness, durability and cleanliness, and adaptability to both foul and purified gases.

See Figure No. 10.

Electrical Pressure Alarm—Mr. Edmund Cathels, Providence, R. I. The float, brass rod and cross bar "C" and "A" and "D" are all soldered up together as if in one piece. The guide columns are made of glass tubing inserted in holes drilled in wooden cover, glass columns are about ¼" outside diameter, and a wire brace keeps them equi-distant on top. The brass guide blocks are drilled so as to slide up and down glass rods. The brass stops "BB" are set at any desired point, by inserting a piece of rubber tape between the stop and glass rod, connecting posts tapped into them for connecting wires.

By connecting gauge as shown, using stop-cock "E" for mouthpiece, the exact pressure at point of alarm can always be obtained by blowing at point "E." The location of push

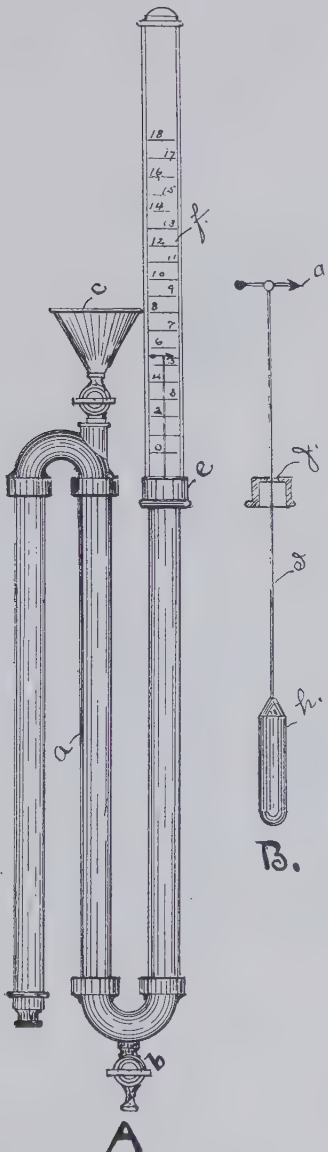
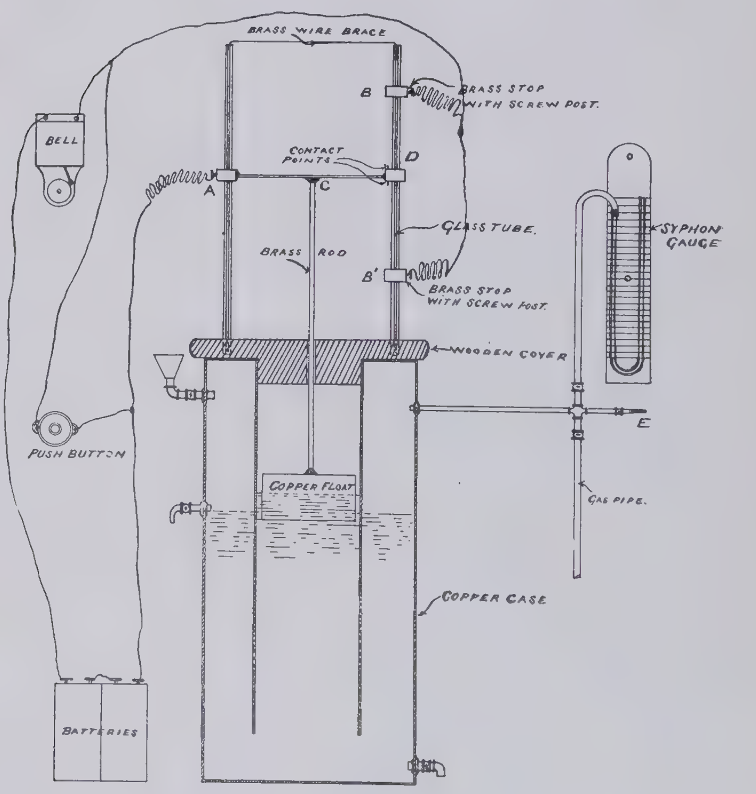


Fig. No. 10.

bottom as shown will always prove the condition of batteries. It is almost needless to say that this arrangement will give an electrical alarm for any pressure or vacuum within its limit, that may be desired.

See Figure No. 11.



ALARM PRESSURE GAUGE

Fig. No. 11.

Electric Pile Driver for Foundations—Mr. George S. Carson, Iowa City, Ia. The picture is of a motor driven pile driver which we rigged up to drive the piling for the foundation of a 150,000 foot steel gas holder we are putting in. With this

outfit we drove 556 cedar pilings in eleven days, one-third of which were fourteen feet long and the balance twelve feet; they were all driven within a seventy foot circle to support an eighteen inch concrete foundation on which the steel tank will rest. To have driven these piling with a horse power outfit would have taken nearly forty days. This may be boosting

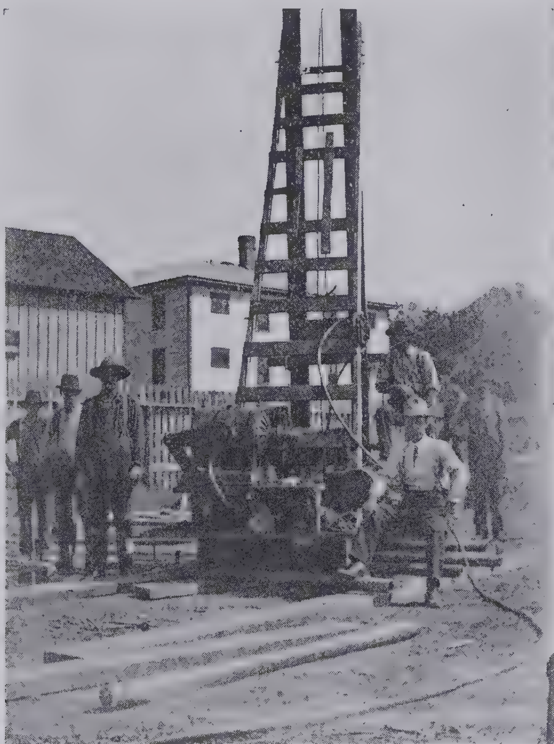


Fig. No. 12.

the electric power business, but we operate both gas and electricity here, so one hand can wash the other.

See Figure No. 12.

Automatic Control of Ammonia Stills—Mr. F. E. Sheriff, Vincennes, Ind. Thermostats for the control of temperatures on ammonia stills have been in operation for some time, and

are proving very successful. They will control the temperature at the inlet of absorber within two degrees, and should the feed pump stop for any reason, the regulator will automatically shut the still down.

The regulation is attained by means of a regulator placed at the top section, which operates a valve in the steam line into the still. Compressed air or water pressure is the motive power used for operating the steam valve. A small hydraulic air compressor may be used if water is dirty.

By means of this regulation liquor of a certain strength is more readily obtained, and close observation of the thermometer is avoided.

Filling Holder With Air—Mr. L. C. Graham, Winona, Minn. Owing to the location of our new 200,000 cubic feet Holder, it was practically impossible to fill it with air for testing, with any apparatus we had.

A steam jet was constructed at a very slight expense and worked successfully. We used a 1″ pipe to convey the steam into a 3″ pipe, which was connected to the top of the inlet drip pot. The end of the 1″ pipe, which entered the 3″ pipe, was reduced to ½″. The supply of air was controlled by 3″ valve on the end of the 3″ pipe, and the holder raised about 3′ per hour. A pump with a metal valve was used to keep the drip pot clear of hot water.

Safety Devices—Mr. Paul Doty, St. Paul, Minn. All workmen should be safe-guarded against accidents, and security of life and limb is the first essential of civilization and progress.

Many accidents are avoidable, and safety and security should be provided for installations of boilers, motors, power transmissions, elevators and hoisting apparatus, transportation and filling of acid tanks, etc. Safety lamps, respirators, ventilators, air purification apparatus to prevent inhalation of dangerous gases, etc., are all to be recommended. The respirator shown covers and protects the mouth and nose against dust, etc. It contains filtering cotton to purify the air inhaled and flaps of mica for the overflow of the exhaled air. The goggles are to protect the eyes.

The oxygen apparatus has a discharge of from one to ten

Fig. No. 15

Fig. No. 15.

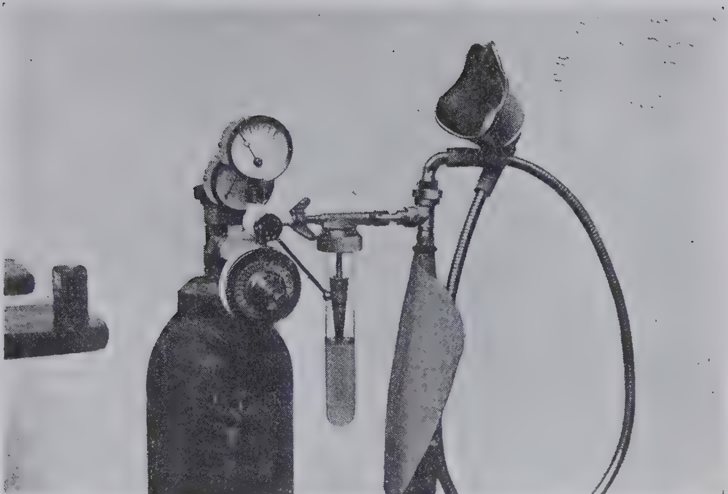


Fig. No. 15.

quarts per minute, and is provided with a water or medicated vaporizer.

The complete asbestos suit with isinglass face protector is used when necessary to be near excessive heat.

See Figures No. 15.

Quick Estimation of Sulphur in Coal—St. Paul Gas Light Company, St. Paul, Minn. By this method one can be ready for the precipitation portion of the test in a few minutes, instead of the slow heating for three or four hours in a platinum crucible over an alcohol flame.

. A sample of the coal to be tested, pulverized to pass a 100-mesh screen, and weighing one-half gram, is mixed with ten grams sodium peroxide (Na_2O_2)and one-half gram potassium-chlorate ($KCLO_3$), the latter two weights being approximate. The method of mixing the charge is to place the weighed sample of coal in the cylinder shown in the figure, mix it by means of a wire with the $KCLO_3$, and then add the Na_2O_2, using a certain measure which you have found amounts to ten grams, mix quickly with a wire and close the cylinder by

screwing on the cap. Avoid exposing the Na_2O_2 to air unnecessarily, as it changes its structure; it is best to use either brass or copper in handling this, avoiding contact with paper, which it would ignite.

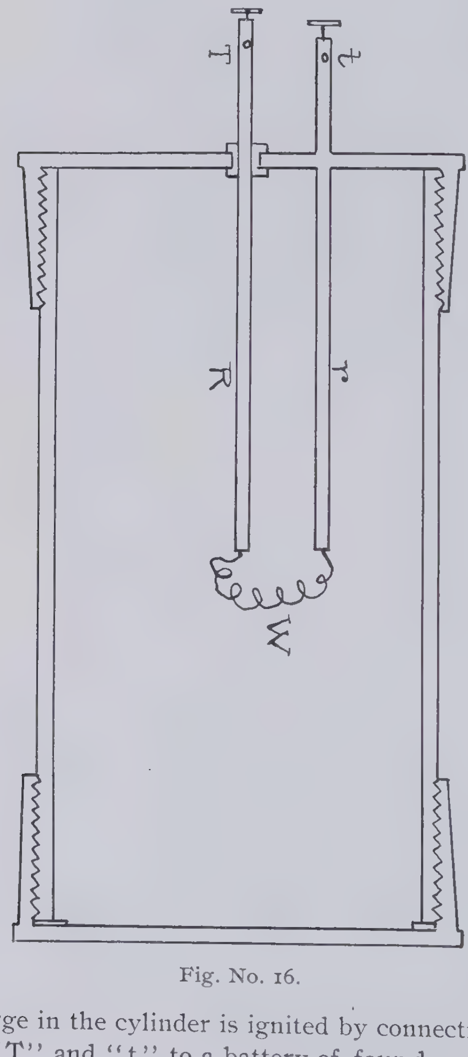


Fig. No. 16.

The charge in the cylinder is ignited by connecting the two terminals "T" and "t" to a battery of four dry cells.

The charge is burned at once, removed from the cylinder,

dissolved with hot water, and the analysis completed in the usual way by adding HCl and precipitation with barium chloride.

The cylinder shown in the figure is of brass, about one inch inside diameter, one-eighth inch thick and four inches long. It may be made from a piece of brass pipe, capping both ends; or by boring out a brass rod and capping the open end in such a way that it may be readily removed for putting in the charge.

One of the rods inside the cylinder is insulated from the outside shell, while the other is in electrical connection with it, the rods being joined at their inside terminals by the fine wire "W" which is about 64 gauge, and becomes heated when the battery is attached.

This shorter method gives greater accuracy than the longer test.

See Figure No. 16.

Holder Heights at Night—Mr. C. H. Gifford, New Bedford, Mass. Six-inch figures are painted on the side of holder, spaced six inches apart. There is a target or pointer mounted on the holder tank to read five feet above the water line, and there is an electric lamp mounted on a rail of the holder tank, one wire being connected to the lamp and the other wire carried to a single pole switch at a convenient point in works.

Sampling Flue Gases—Mr. E. W. Gutsche, Everett, Mass. Finding it necessary to take flue gas samples three feet back from the peep hole in a retort furnace, I experienced difficulty in finding a tube which would withstand the high temperature, using material at hand. After some experimenting, I found that a piece of good ignition tubing, tightly wound with asbestos wicking, served the purpose very well. The ends of the wicking can be fastened with a little fire clay which, when baked, firmly holds the wicking. A piece of ignition tubing ¼ inch in diameter thus wound with the asbestos, makes a cheap, handy and very servicable tubing for sampling gas where temperatures are high.

District Pressure Booster—St. Paul Gas Light Company, St. Paul, Minn. Two districts across the river "L" and "H"

from the works "W" are supplied by two feeder mains of six and eight inches in diameter respectively.

District "L" is lower than the works, while "H" is higher. Although pressures in "H" were good, it was found difficult to maintain pressure in district "L" at hours of maximum demand.

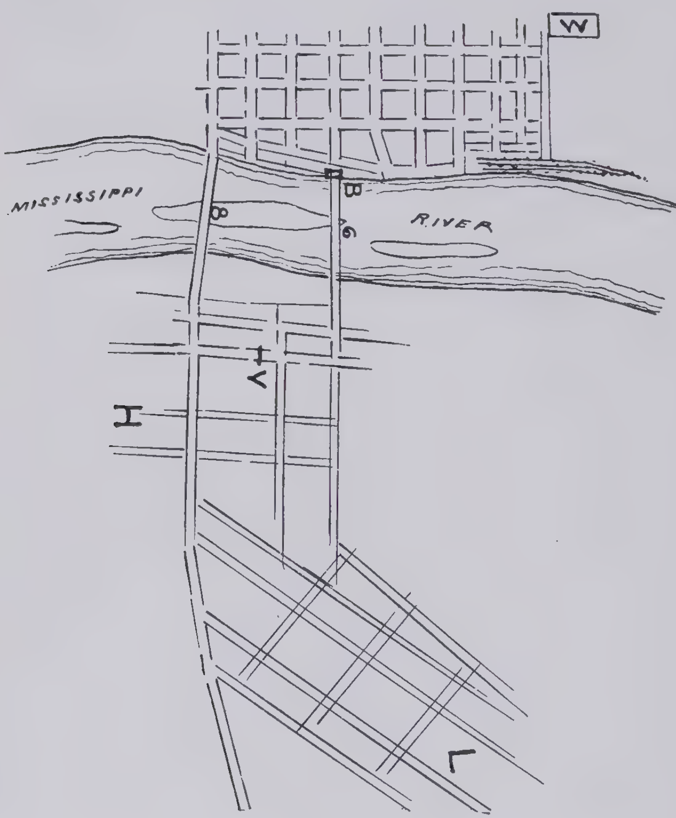


Fig. No. 18.

To correct this, a blower, direct connected to an electric motor, was cut in the six-inch main at "B," and the pressure at that side of the bridge raised to nine inches, giving about five inches on the opposite side. The pressures are now satisfactory.

"B" is about a mile from the works. The six-inch main is connected to large twelve-inch main at both ends, giving sufficient capacity of gas to prevent any pulsation being noticed.

The valve "V" prevents gas backing through the eight-inch feeder. See Figure No. 18.

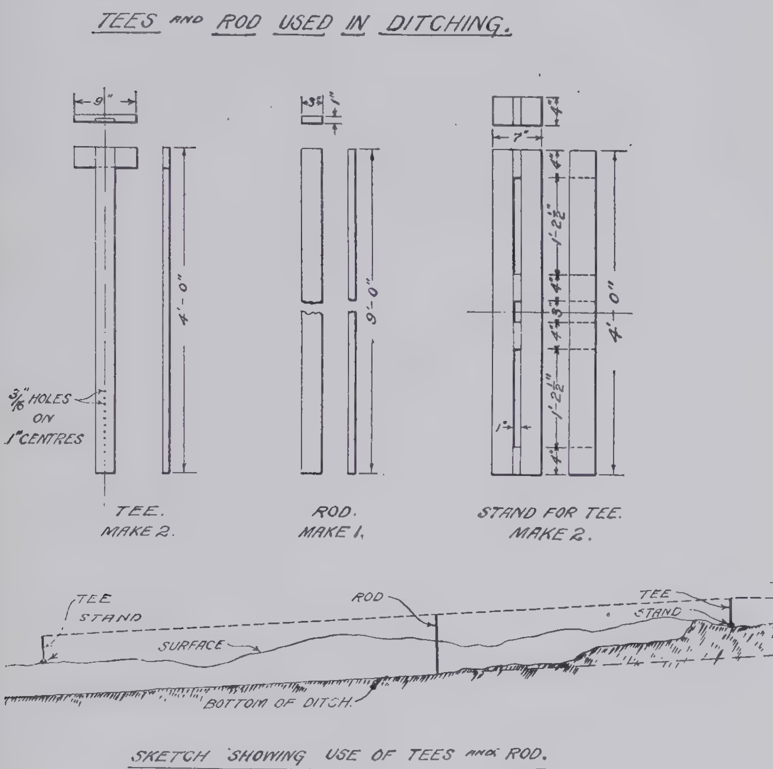


Fig. No. 19.

Tees and Rod Used in Ditching—Mr. W. A. Castor, Philadelphia, Pa. The tees and rod are made of 3″ x 1″ planed white pine. The stand is built of two pieces of 3″ x 4″ rough hemlock separated by full 1″ distance pieces. The blade of the tee slides up and down through the small slot in center of stand. Adjusting of tees in stand is accomplished by means

of wire pins passed through 3-16″ holes bored in blade of tees, the ends of the pins resting on the stands when tees are in position. Red paint is used on head of tee and white paint on end of rod for contrast when sighting between tees.

The rod shown in the sketch is used for ditching for 20″ main. An adjustable rod could be made suitable for all sizes of main to be laid.

By using the stands for the tees it is not necessary to have ditch open at the time of setting the tees, nor are the tees in the way of the workmen in the ditch. These tools have greatly assisted the work when bucking grades on paved streets, and when excavating in places where the surface is rough or uneven. We have found these tees and rod indispensable in setting blocking for large pipe ahead of the derrick gang.

See Figure No. 19.

Rope Mats for Blasting—Mr. A. C. Pease, Lowell, Mass. A simple contrivance for weaving rope mats for ditch blasting

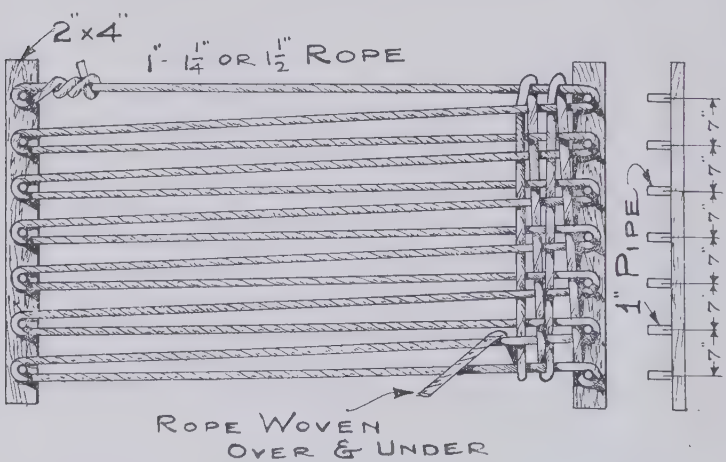


Fig. No. 20.

is made of 1″ pipe struck into 2″ x 4″ lumber and set up on wooden horses.

The mat is fastened down by logs, which are chained down or not, as may be required.

A mat 7′ x 12′ made of about 1400 feet of 1 ⅛″ rope weighed about 700 pounds. This was a large mat used for special blasting. See Figure No. 20.

Cleaning Pipe—Mr. W. A. Castor, Philadelphia, Pa. Worn

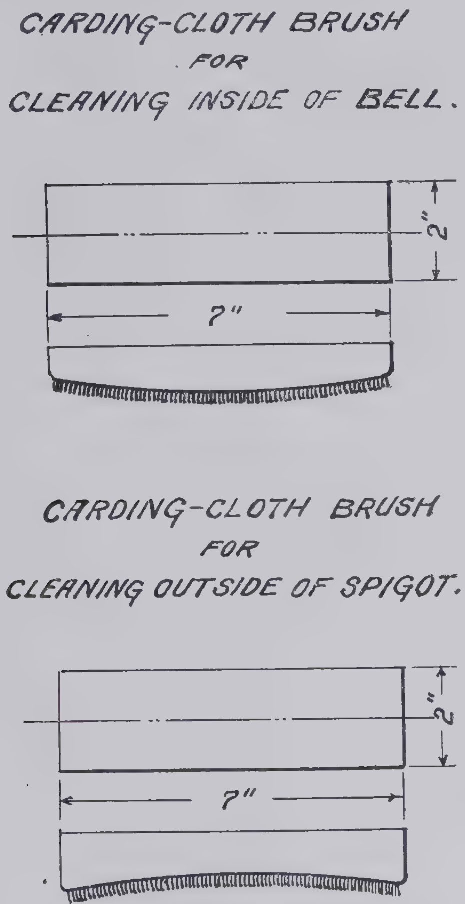


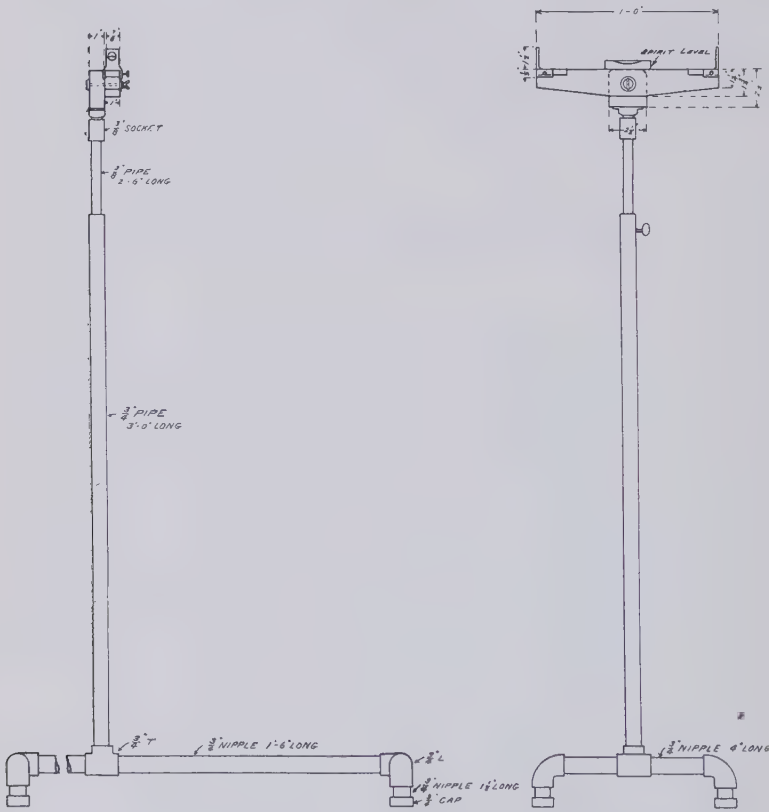
Fig. No. 21.

out carding cloth obtained from a cotton or woolen mill and nailed to a soft wood backing and cut either convex or concave to fit the pipe, makes excellent brushes for removing all rust and scale from bell and spigot ends.

The brushes do the work much better than the ordinary steel foundry brush, and last equally as long. We have found them to be of great service in preparing large pipe surfaces for cement joints.

See Figure No. 21.

Leveling Mains—Mr. W. A. Allison, Philadelphia, Pa. This wrinkle consists of a sighting level, target and leveling rod, which arrangement we find to be very useful in ditching and laying mains. It frequently happens that we are called upon



SIGHTING LEVEL

Fig. No. 22.

to lay mains in streets that are very irregular in grade, and the use of this wrinkle permits us to dig trenches and adjust the main blocks with such precision as to render unnecessary the use of the hand level in grading, after the pipe has been placed in the ditch. It is adjustable and permits of much more accurate work than the ditching tees commonly used for the same purpose. In addition to the use of the device for

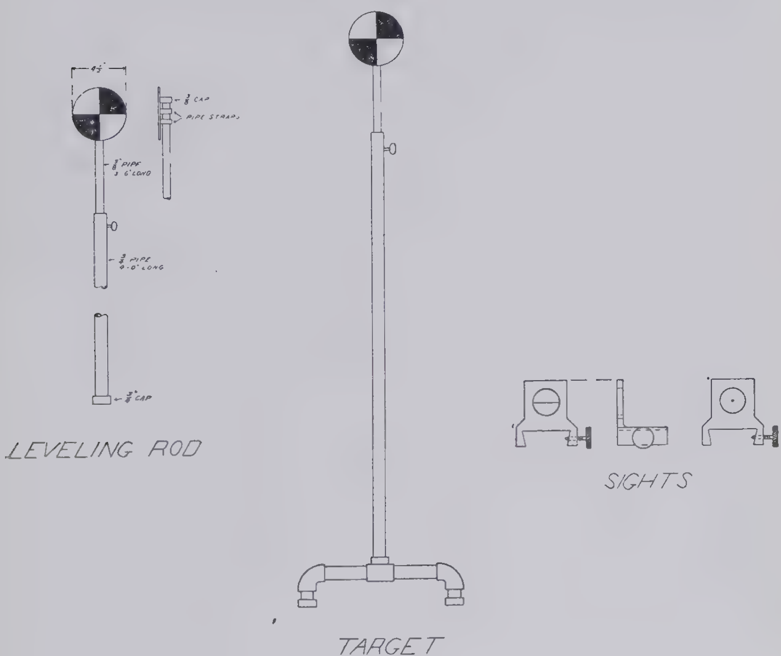


Fig. No. 22.

ditching, it may be used as a level for determining the difference in elevation of underground structures.

See Figures No. 22.

Connecting to a Small Branch on a Large Main Without Bagging Off the Large Main—Mr. W. H. Smith, Philadelphia, Pa. Where a branch connection has to be made to a larger main, and a small branch line exists, and the opening is being accepted, in order to make the new connection without bagging the large main, proceed as follows :

After bagging the branch line as close to the large main as it is possible, cut off the pipe as near to the bag as safety will permit; then insert a climax stopper soaped, and as the bag is withdrawn push the stopper past the bag hole until it is beyond the end of the pipe to be removed and in the neck of the branch, and then expand the stopper. Then cut off the pipe close up to the branch with a cutter, or remove it from the branch without cutting off, if possible.

The original bent stem of the stopper must be removed from the discs and a straight stem substituted, sufficiently long so that when the reducer, or piece of pipe to be used for a connection, is slipped over it, the thumb nut will be outside; over the new stem a piece of 1″ pipe must be used between the discs and thumb nut. The mode of withdrawing the stopper is the reverse of that of inserting it.

Permanently Plugging a Small Branch on a Large Main Without Bagging Off the Large Main—Mr. W. H. Smith, Philadelphia, Pa. Bag off the small pipe as close to the branch as it is possible to get the tapping machine on. Then cut off the pipe as close to the bag as safety will permit; then insert a round disc of wood three inches thick, made by cutting it from a wood plug at the diameter where it fits the pipe best, but not tighter than will allow of its being driven into the pipe.

Drive this disc through the pipe, after removing the bag, until it is located in the neck of the branch, and there it is to remain. Then remove the balance of the pipe and insert the permanent plug.

Permanently Plugging a Small Branch on a Large Main Where a Wood Plug Now Exists, Without Bagging off the Large Main—Mr. W. H. Smith, Philadelphia, Pa. As the wood plug is likely to be driven in very tight and the end protruding beyond the face of the bell, first saw it off close to the face of the bell, then by the use of a sharp wood chisel, cut into the wood from center to outside, until it has been removed to the bottom of the bell. Then insert permanent iron plug after scraping off all foreign matter from inside of bell.

Valve Box and Locations—Mr. L. R. Dutton, Wyncote, Pa. The cut shows, first, a small cast iron lid over an ordinary terra-cotta pipe, which is used for cheaper construction than an iron box over valves, drip-stems, etc. The post at the right is a 4″ x 4″ wooden post painted white with black figures to designate the exact location of valves, drip-stems, etc., along the highways in suburban districts where the street lines are not designated by permanent paving from which records can be made. Both the above have been found of good service on several miles of high-pressure lines that have recently been laid through the ordinary roadways in suburban districts.

See Figure No. 26.

Stop Box for Sidewalks Hollow Underneath—Contributed by Milwaukee Gas Company, Milwaukee, Wis. The "hollow sidewalk box" was gotten up to cover the fire department's demand for an emergency stop to be used in case of accident or fire. Such a box must fulfill the following conditions:

It must be cheap, that is, there cannot be much, if any, machine work on it.

It must be absolutely water tight, as many people store perishable goods under the sidewalks in these days.

It must not be possible for any meddlesome person to so tamper with the box as to either leave the cover off or to leave it in anything but water-tight condition.

It must be possible to instantly open the box in any weather without special tools, and after having opened the box the arrangement for turning the stop-cock should be extremely simple, and so placed that the fire department men, under the most unfavorable conditions, will have no difficulty in reaching the head of the stop-cock.

See Figure No. 27.

Service Kit—Mr. F. M. Arthur, Philadelphia, Pa. I submit herewith a photograph of service kit as used by us in the Philadelphia Gas Works. The outside dimensions of this kit are 2½″ x 6½″ x 13″. It contains the following articles:

1 ten-inch trimo.

1 hammer.

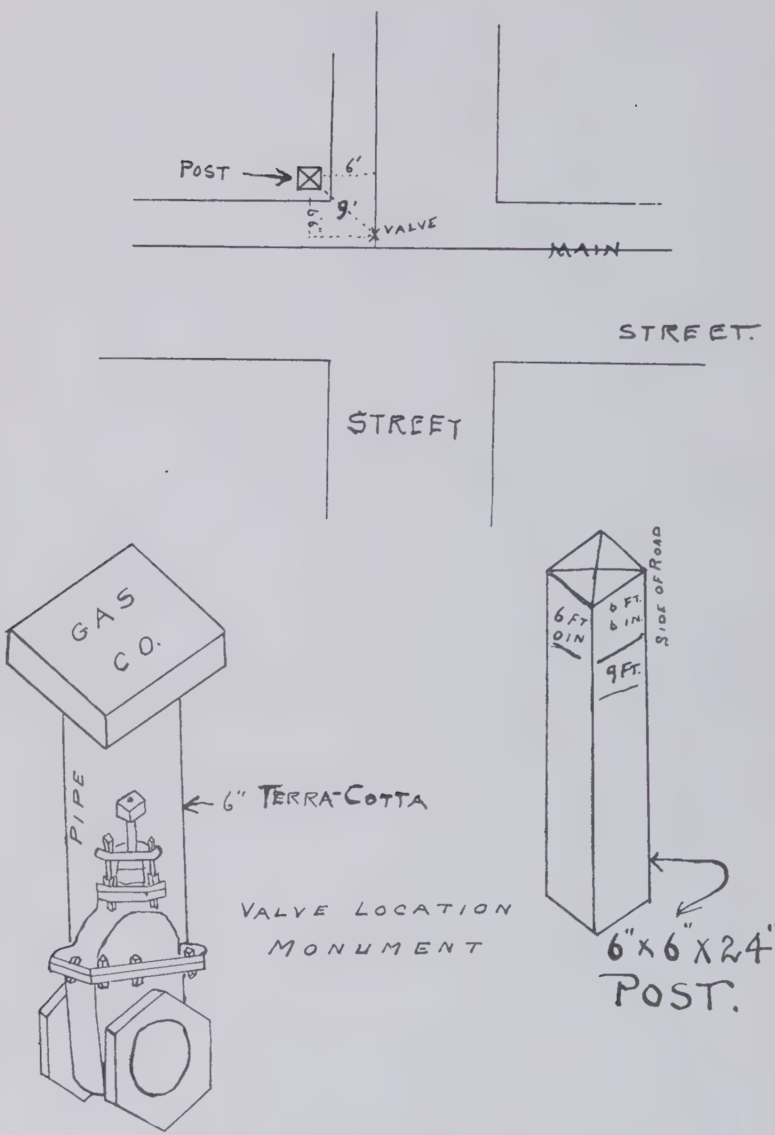

POST
6'
9'
6'
VALVE
MAIN
STREET
STREET
GAS CO.
PIPE
6" TERRA-COTTA
VALVE LOCATION MONUMENT
6 FT 0 IN
6 FT. 6 IN.
9 FT.
SIDE OF ROAD
6"x6"x24" POST.

Fig. No. 26.

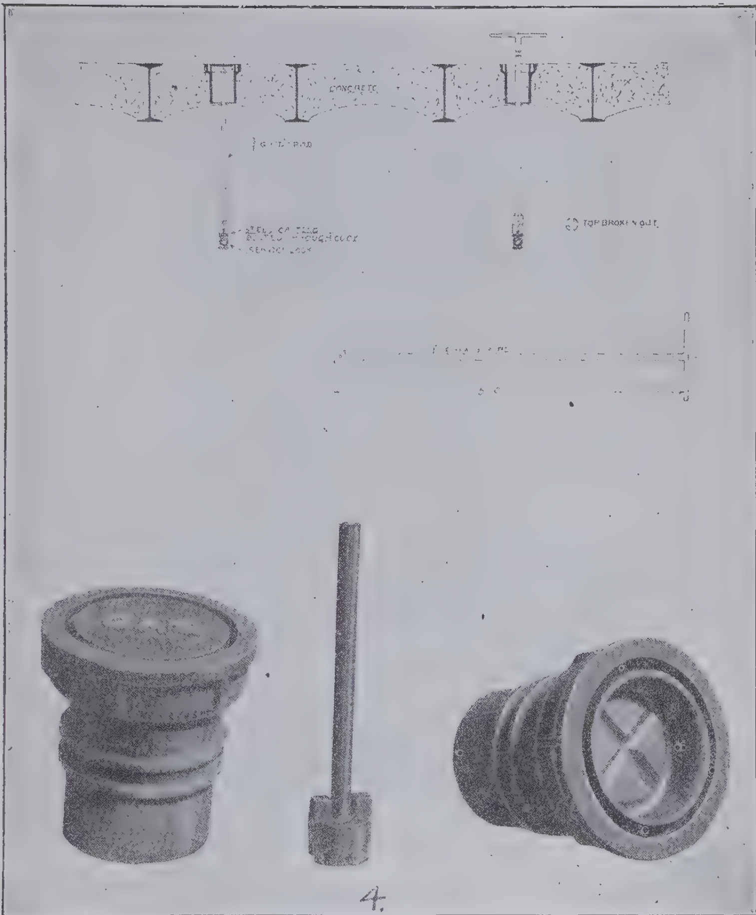


Fig. No. 27.

1 burner plyers.
1 screw driver.
1 six-inch cold chisel.
1 set (six) stove reamers.
1 six-inch three-cornered file.
1 meter test cap.
1 tube of fitters' cement.
1 box of soap.

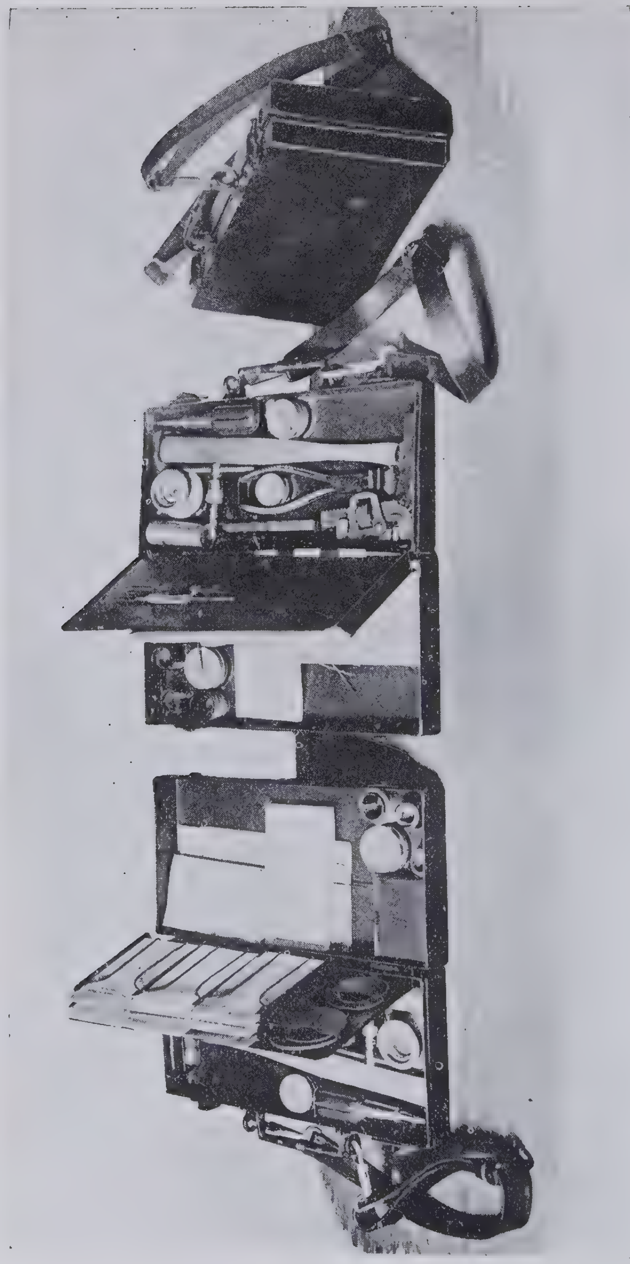


Fig. No. 28.

1 box of key grease.

1 box of stove cement.

2 dozen Bray burners.

Full supply of meter washers from 3 lt. to 100 lt., inc.

14 kinds of order and report cards, each kind in a separate compartment. See Figure No. 28.

Cutter for Lead Pipe—St. Paul Gas Light Company, St. Paul, Minn. In making up lead connections for meters, the tool shown in the figure is used for cutting the lead pipe.

It has sharp cutting edges on the face of each jaw, and saves time over other methods, a half turn of the tool being sufficient to cut the pipe. It is possible to cut two hundred pounds of lead pipe in twenty minutes with this tool.

No burr is left on the pipe, and there is no waste as when using a saw. See Figure No. 29.

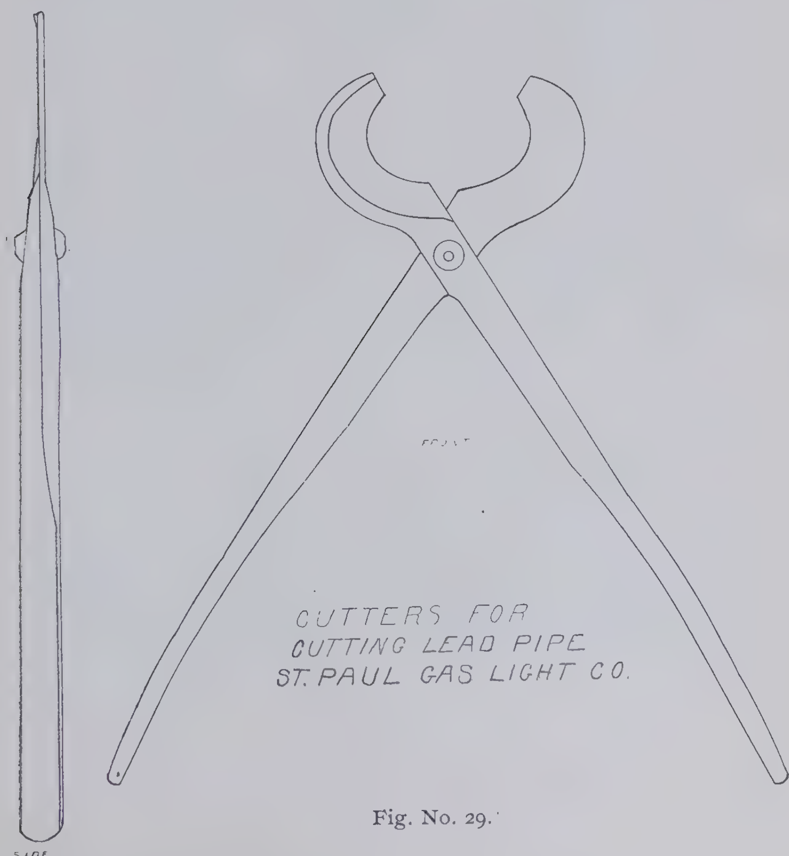


Fig. No. 29.

Appliance Wagon—Mr. W. B. Perkins, Altoona, Pa. The wagon is intended and is built for the sale of all small gas appliances. One of the cuts shows the side of the wagon opened, exposing shelves upon which samples of what the wagon contains will be exposed. Another cut shows the interior arrangement, which is composed of bins of various sizes, and in which the stock is to be kept. It is proposed to keep this wagon on the street all the time, visit every gas consumer in the city, look over his gas consuming appliances,

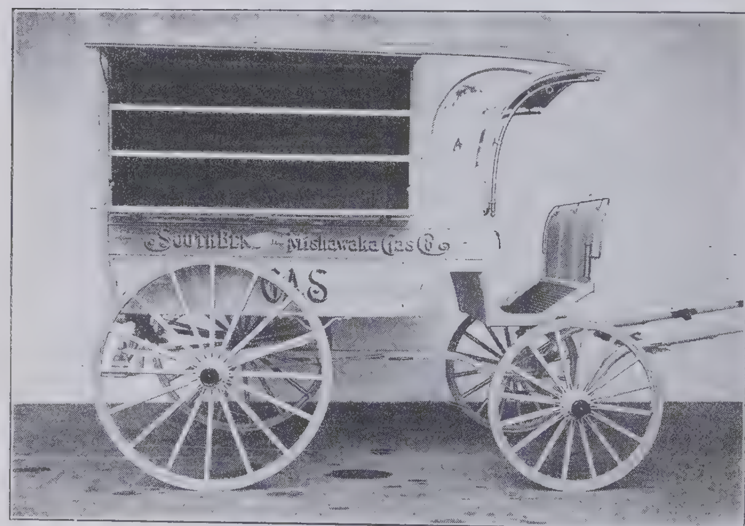


Fig. No. 30.

repairing such as need it, and supplying parts that might be necessary to insure good service.

It is expected that the profits from the sales from this wagon will maintain it, and it goes without saying that it will be a very good advertisement for the company.

See Figures No. 30.

Portable Step for Lamp Lighting—Mr. G. W. Shorday, Wyncote, Pa. The cut shows a small iron step weighing a couple of pounds and can be made by a blacksmith from

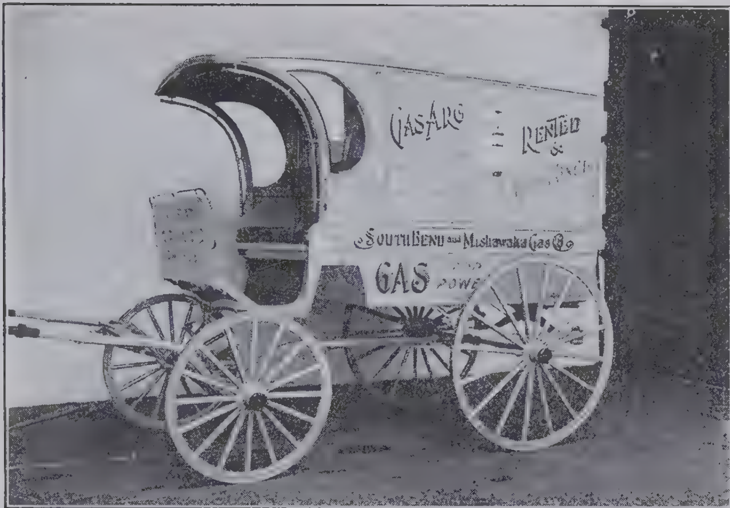


Fig. No. 30.

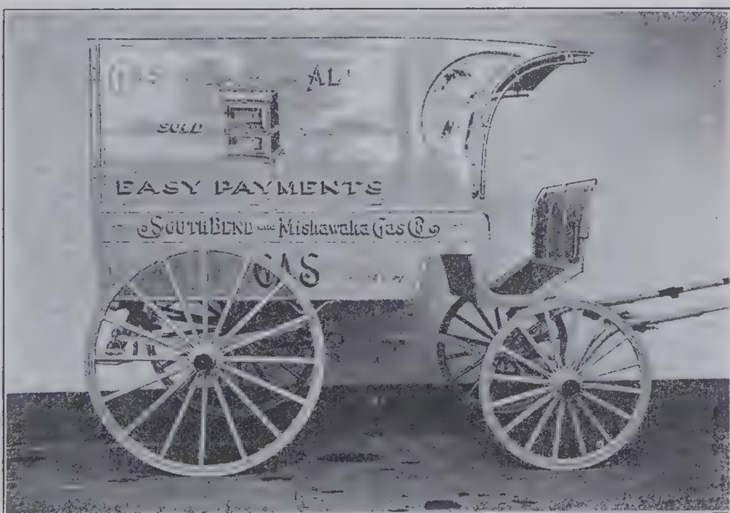


Fig. No. 30.

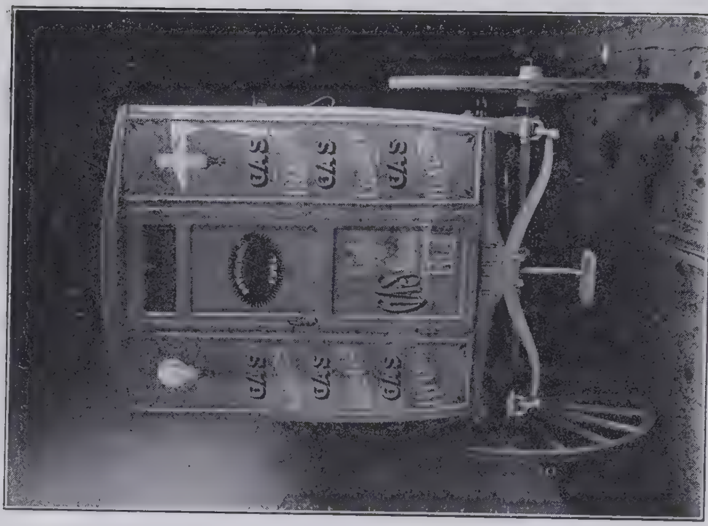


Fig. No. 30.

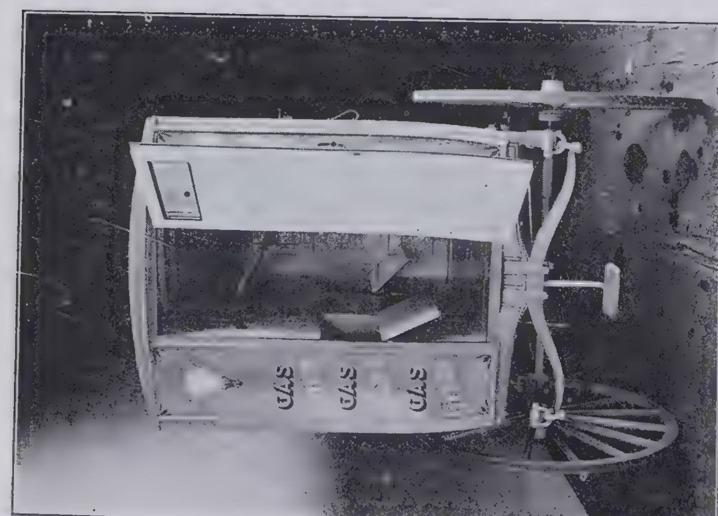


Fig. No. 30.

1″ x ¼″ strap iron for the use of the lamp lighter to suspend above the projections which are usually on an iron lamp post about three feet from the ground.

The small step is much handier, much lighter, and will serve same purpose as a 4 or 6 foot ladder which is usually carried by the lamp lighter.

See Figure No. 31.

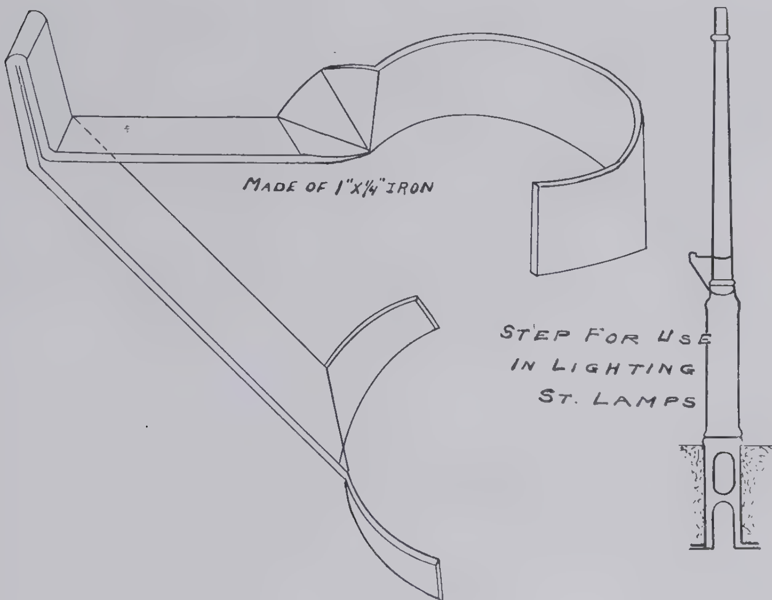
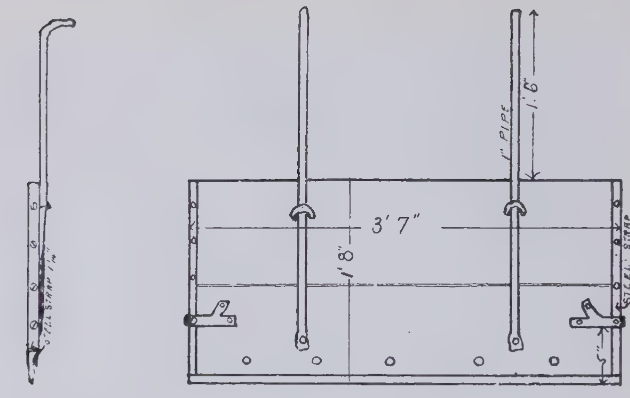


Fig. No. 31.

Scraper for Refilling Ditches—St. Paul Gas Light Company, St. Paul, Minn. A scraper that can be made in any blacksmith shop and has been found very useful in refilling ditches after laying main in the outlaying portions of the city, will save a large amount of labor that is otherwise found necessary.

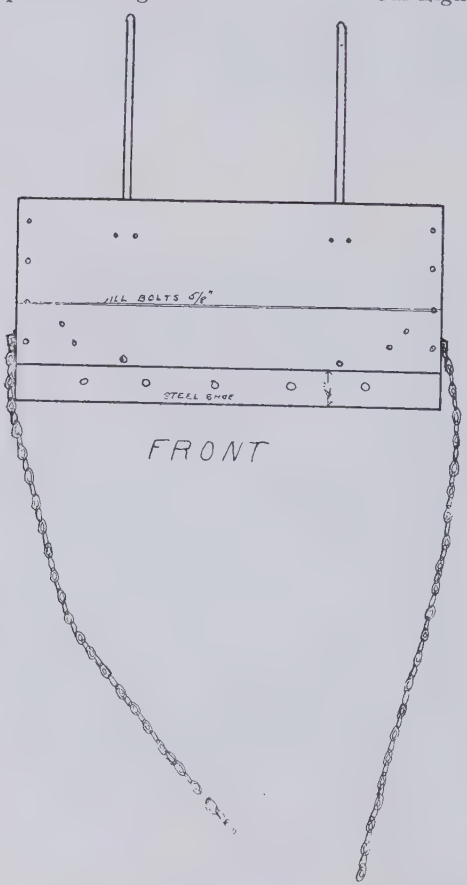
With this scraper, as shown in the figure, work that would require fifty men working without the scraper, can be done with thirty men working with the scraper. A team and two men can fill one thousand feet of ditch in a day.

See Figures No. 32.



Front Back

Scraper for Filling in Trench.—St. Paul Gas Light Co.



Figs. No. 32.

Maintaining Outdoor Gas Arcs—Mr. R. A. Field, Rome, N.Y. We found that it was necessary to wash the globes oftener than it was to renew the mantles, but while the globe was being washed the wind would often blow the mantles off the lamp, necessitating a complete mantle renewal every week when the globe was washed.

We now send out two men with one extra globe and collar. Placing the ladder on the windward side of the lamp so that the body in a measure protects the mantles, one man removes the globe, passes it to his helper on the ground, receives the clean globe and collar and slips them unto the lamp. The whole operation does not take more than 20 seconds.

The globe which was removed is then cleaned and carried to the next lamp.

By this method mantles are rarely lost, and there is an actual saving in the cost of labor per lamp on account of the rapidity with which they can be gone over.

Securing and Training Meter Readers—Mr. J. M. Robb, Peoria, Ill. One of the most vexing problems of the average gas man is to get his meter read without interfering with his shop work.

We have tried the following scheme in Peoria for two months with such good results that I feel warranted in offering our scheme as a Wrinkle.

In July, we advised the Y. M. C. A. and the business colleges that we wanted a number of young men to read meters. We very soon had a number of applicants, each of whom was requested to be at our office at a certain time a few days in advance of the beginning of our meter reading.

At this appointed time we had ready about twenty-five old meter dials, which were set at points where mistakes would be most probable, and the applicants were asked to take the statements. The dials were then changed, the statements noted and again taken by applicants. The process was repeated until each man had read a hundred meters, when his work was checked up. The applicants making the best showing at the examinations were selected to read meters.

The results have been satisfactory. The men so chosen

have in some cases turned in more statements per day than our men regularly used on such work, and but few mistakes have been made.

Another advantage in selecting our meter readers in this manner arises from the fact that many of the young men are from our best families. We feel that the knowledge they have gained of our business methods will be spread in a manner which is bound to help us.

If at any time we should lack applicants for this work, we intend to advertise for young men in the space we use for advertising our business.

Map and Tack System—St. Paul Gas Light Co., St. Paul, Minn. This is a system of maps and tacks affording a ready reference to work carried on by the distribution department.

Maps showing all the streets in the city are mounted on frames sliding in a cabinet holding six maps.

By a system of different colored tacks, all main extensions, service orders not executed and location of all crews are kept in such shape that one can tell at a glance just what is being done by the distributing department.

Under our plan, when a service order is issued, a white tack is placed on the map at the location indicated in the order, showing that a service is to be run there.

When an order for a main extension is received, a tack of different color is selected—various colors being used to indicate the size pipe ordered, and if the extension is of considerable length, the pins are connected by thread of the color representing the size main.

The location of the service crew is indicated by a numbered tack, the number corresponding to the number of the crew it represents.

A glance at the map shows both the *number* and *location* of (1)—service orders unexecuted; (2)—service crews at work; (3)—main extensions and size pipe.

When a service order is returned executed, the pin representing it is removed; if a main order is returned executed, a line is drawn of the color representing the size of pipe used. Changes of location of pins representing crews is made as often as necessary, the map being revised each morning.

The method of using the system may be varied to suit local conditions. It is useful in being able to locate quickly the service orders, crews and main extensions.

Method of Showing Sales—St. Paul Gas Light Company, St. Paul, Minn. For showing quickly and prominently the sales to date, a face of a clock thirty-six inches in diameter is

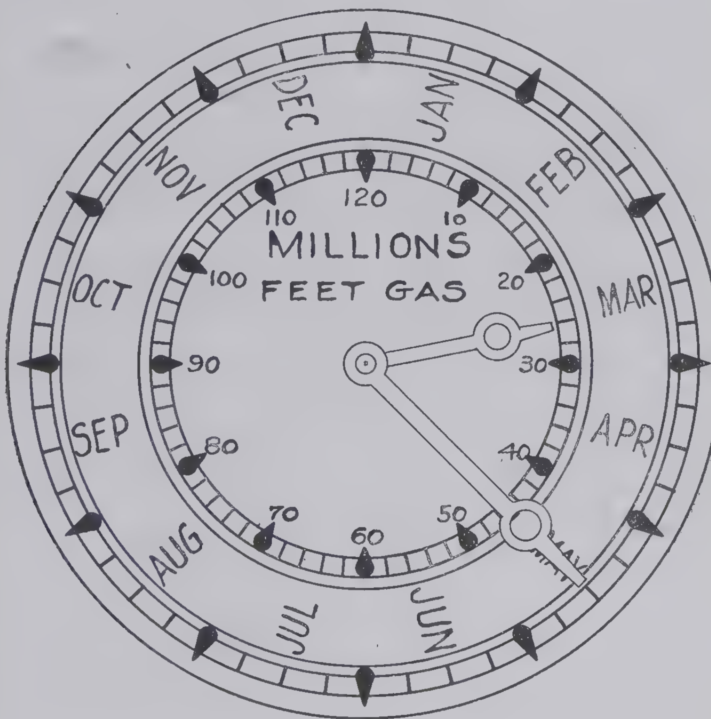


Fig. No. 36.

especially designed for hanging on the wall to show at a glance the sales for the year from January 1st to date.

The large, outside hand shows the time over which the sales period extends from January 1st, and the inside hand shows the quantity of the sales during this time.

Two clocks are used by this company, one for showing the number of gas ranges sold since January 1st, and the other

for the gas sales increase in cubic feet from January 1st to date.

The relative positions of the two hands show the rate of sales; the two hands should move around the face of the clock together if the sales are up to the established standard.

See Figure No. 36.

Advertising—Mr. George P. Knapp, Delray, Mich. A display of traveling bill-board which reaches all parts of town.

See Figure No. 37.

Fig. No. 37.

Coal Gas Costs and Credits—Mr. D. G. Fisher, St. Louis, Mo. A chart or diagram of curves from which may be obtained by direct reading the credit in cents per M. of any residual at any price per unit at any yield, together with the charge for any number of pounds of bench full per ton of coal carbonized at any price per ton, has been prepared by

Mr. Fisher, who will be pleased to mail blue prints to anyone interested.

Why Complaint—Mr. John C. D. Clark, St. Louis, Mo. It seems that the gas companies, as far back as I can remember, have always used the word "complaint." I believe if we went back into ancient history we would find that gas companies originated the word. Then in order to impress it on everybody, they print it on their stationery, work tickets, etc. Of course, this is a good word to promote business along this line, but I think it does not look like good business.

I do not understand why a person should be called on to come to the gas office and make a *complaint* when he has a simple inquiry to make of the company in reference to the amount of money he pays the company for gas, or some other inquiry he may wish to make in reference to his account. Neither do I understand why it should be considered a complaint if some service the company is supposed to render the customer is not being done to his entire satisfaction.

I think it would be a much better plan if the gas companies would forever drop the word "complaint" when carrying on their business with their customers. We think that the words "inquiries" and "requests" would cover the ground fully. If a customer calls on the company to make an inquiry in reference to the amount of money charged to him on his bill, it should be taken up in a business like way, and his inquiry answered fully; but he should not be treated in the light of complaining; he is simply seeking information which should be accorded him as far as possible. If we were not in possession of the information and he is or should be, if he can be told in the proper manner he will go away feeling that his inquiry has been answered. But if you treat this man in the light that he is making a complaint, he feels though he has to be pretty mad before he comes near the office, and the first thing he wants to do is to quarrel. If, however, he finds on arrival at the office that the company is willing to answer every inquiry, and afford him every means for enlightenment, he is not going to feel bad about it at all.

Again, if there is a defect in the service and customer

requests that it be made right, he should be able to state his case and have his rights without being treated as a man making a complaint.

Detachable Gas Stove—Mr. Donald McDonald, Louisville, Ky. This little stove has been made specially for that class of people who want a gas stove occasionally, but are not willing to keep one connected up in the room at all times. The stove stands 15 inches high, and it is 9 inches in diameter. It is primarily a heater, but the top is made flat, so that a vessel can be placed on it for boiling. When the stove is not in use it can be put away in a closet, and when it is desired to use it all that is necessary is to place it on a combined floor flange and stopcock and turn the gas on by turning the stove around.

It is so arranged that the stove cannot be taken off the spud without first turning the gas off, in this way making an accident impossible. The floor flange is entirely unobstrusive, and unless the stove is actually in use, there is nothing in the room to suggest that it was ever there.

Recording Holder Gauge—Mr. H. H. Hyde, Racine, Wis. The apparatus consists of a galvanized tank of about 10 gallons capacity, a piece of metallic hose connected to a ¾-inch pipe line leading to the gauge; compression chamber, which is made of 3-inch or 4-inch pipe with a glass gauge to show level liquid; a ¼-inch air pipe which connects to the gauge. The gauge is of the ordinary high pressure type with reverse spring. When the pressure is highest, the pen records on the lowest line and vice versa. This arrangement being necessary to correct the action of the tank, which is opposite to the holder. The gauge must have a spring especially calibrated for the certain conditions, as the difference in altitude between the gauge and the tank determines the pressure which actuates the pen. In our case the pressure is about ten pounds when the tank is at the lowest point, and thirty-five pounds at the highest. In determining our pressures we used a mercury gauge and got the actual pressures in inches of mercury. Kerosene is used in the apparatus, as there is no way to prevent water freezing. We have had very little trouble and, with one or two exceptions, have obtained complete records of

the height of our holder at all times. The only trouble being caused by leaks in the hose connections due to high winds.

See Figures 41.

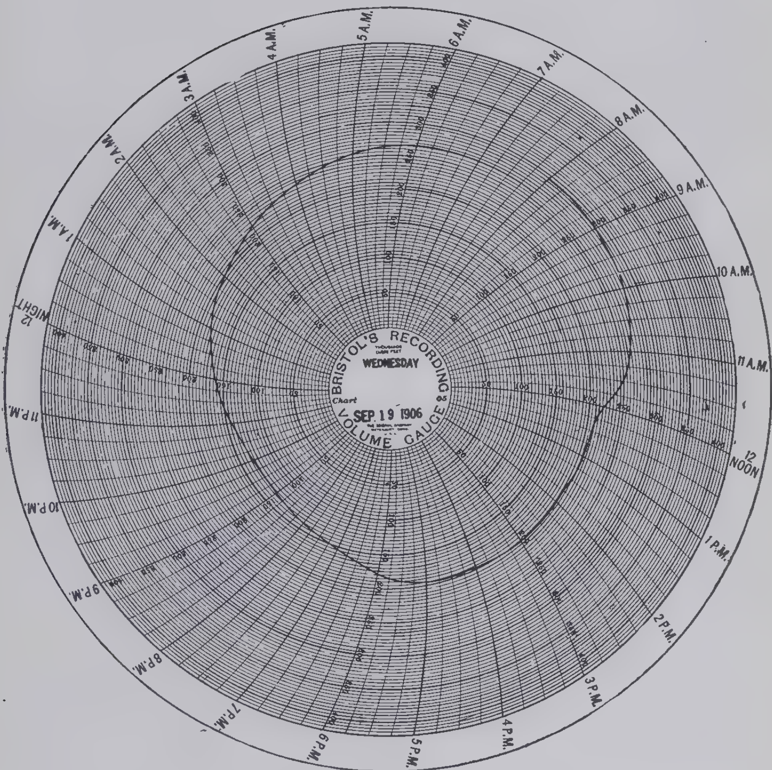


Fig. No. 41.

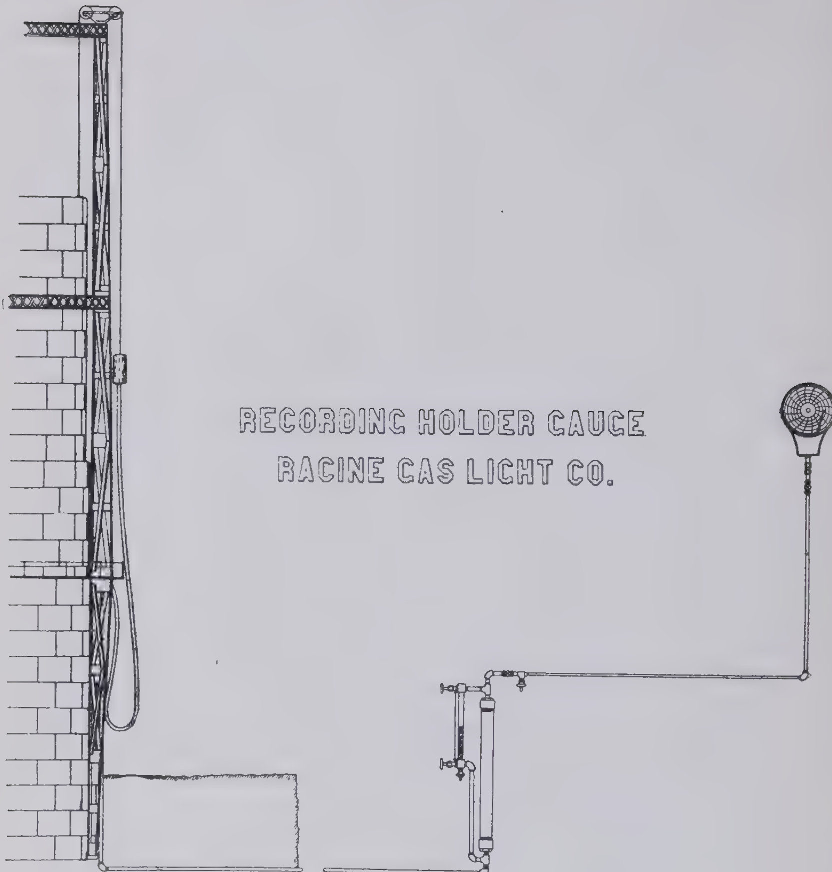


Fig. No. 41.

Drip and Gate Marker—Mr. Francis Engel, Elizabeth Gas Works. In high pressure and long distance gas transmissions on country roads it is not always easy to find a place for a bench mark.

In such cases we set opposite the point, but not too conspicuously, a 1½ inch wrought iron pipe with a tee and short pieces of pipe branching from each branch of the tee to steady the pipe in the ground and make it hard to pull up. On the top of the pipe we also put a tee to give it a finished appearance; a 1½ x 1½ inch tee for drips, and a 1½ x 1 inch tee for

gates. This device will save time usually spent in searching. It can also be used as a hitching post.

Continuous Test for Naphthalene—Mr. F. M. Travis, Torrington, Conn. The cut illustrates an apparatus for detecting naphthalene in the gas, and is self-explanatory.

See Figure No. 43.

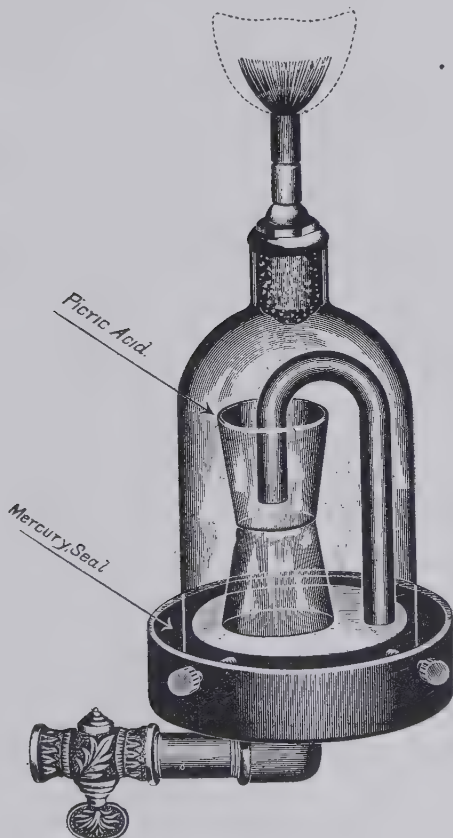


Fig. No. 43.

THE PRESIDENT: We will now listen to a letter from Mr. A. G. Glasgow in relation to his report on Electrolysis. Mr. Glasgow is not here to give it. It will be published with

the proceedings. I will ask the Secretary to read the letter which Mr. Glasgow has submitted concerning the report.

Secretary Dunbar read the following letter:

LONDON, S. W., September 26, 1906.

Referring to Report of Electrolysis Committee.

John Williamson, Esq.,

157 Michigan Avenue,

Chicago, U. S. A.

MY DEAR WILLIAMSON:

I find that I shall not be able to return to America in time to attend the next and last meeting of the American Gas Light Association, so I want you to take charge of the presentation of our Electrolysis report.

I think we should arrange for the continuance of the committee by the new Gas Institute, inasmuch as this question of electrolysis is a very live issue, and information is continually accumulating regarding it, not only in America, but in all parts of Europe. It will, therefore, I think, be useful for us to submit additional reports from time to time (not every year) bringing the status of this subject up to date.

I am very sorry indeed that I shall not be with you this year, and I wish the last meeting of the American Gas Light Association and the first meeting of the American Gas Institute all possible success. It is a case of "The King is dead! Long live the King!"

With kind regard,

Yours very sincerely,

A. G. GLASGOW.

SECRETARY DUNBAR: I will state that this report which was made to the American Gas Light Association has been printed and forwarded to the members of the association. Is that not right, Mr. Ramsdell?

MR. RAMSDELL: Yes.

SECRETARY DUNBAR: I move, Mr. President, that this report be included in the proceedings.

Motion seconded.

REPORT OF COMMITTEE ON ELECTROLYSIS.

To the President, Officers and Members of the American Gas Light Association.

SIRS:

Your Committee on Electrolysis begs leave to submit the following Report.

INTRODUCTION.

Mr. Beal's Presidential Address at the Annual Meeting of this Association in 1902 contained the following recommendation:

"I should like to see a Committee appointed which would make a careful investigation of this whole Problem [of Electrolysis] and render a Report in such form that it could be used by Managers in framing arguments for presentation before the Local Authorities."

This recommendation of Mr. Beal led to the appointment of a Committee which is now constituted as follows:

ARTHUR H. HALL, of New York,
S. P. CURTIS, of Philadelphia,
JOHN WILLIAMSON, of Chicago, and
A. G. GLASGOW, of London, Chairman;

and your Committee has been fortunate enough to secure the co-operation of ALBERT F. GANZ, M. E., Professor of Electrical Engineering at the Stevens Institute of Technology.

The geographical distribution of the Members of your Committee, which has made their close collaboration impracticable, was doubtless intended to ensure that their work should cover a wide range of territory; and this Report has been framed in the endeavor to meet your reasonable expectations in this respect. It consists of Five Sections, namely:

This report is limited to the consideration of direct-current electricity, and is, therefore, contingent upon future developments in the use of alternating-current electricity for traction purposes.

There being no meeting of The American Gas Light Association after this report was prepared, it was presented to the American Gas Institute, as a Contribution from The American Gas Light Association.

I. Theory of Electrolytic Corrosion.
II. Electrolysis in America.
III. Electrolysis in Great Britain.
IV. Electrolysis in Germany.
V. Summary and Conclusions.

Your Committee advances no new theories and can suggest no new remedies. It avoids controversial treatment, and deals solely with the indisputable facts that have been developed by experience. To this end, the Committee's endeavor has been to establish authoritatively the universal state of the art of electric traction with reference to Electrolysis. When this is accomplished, the logical conclusion becomes self-evident, and is the same in all countries.

Section I.

Theory of Electrolytic Corrosion.

By Professor Ganz.

Electric conductors are divided into two classes, namely:

1. *Metallic conductors*, which transmit electric currents without chemical decomposition, and

2. *Electrolytic conductors*, or *electrolytes*, which transmit electric currents by a corresponding transfer of *ions* in a solution, thus producing chemical decomposition at the electrodes.

The metals are the most common *metallic conductors.*

Chemical compounds in solution, which can be decomposed by an electric current, are *electrolytic conductors* or *electrolytes.*

Pure water has such a high resistance that it may practically be considered a non-conductor. Water is made conducting by the addition of salts or acids in solution, and conduction through water is therefore always *electrolytic.* For the present purposes we need only consider the electrolytes consisting of salts dissolved in water.

The conducting terminals by which the current is led into and out of an electrolyte are called *electrodes.* The electrode by which the current enters is the *anode*, and the one by which the current leaves is the *cathode.*

The following brief explanation of *electrolytic conduction* is in accordance with the modern theory of *electrolytic dissociation:*

When a salt is dissolved in water, some of the molecules separate or dissociate into two parts, one part having a positive electrical charge, and the other a negative electrical charge, and these parts are called *ions.* The metal part or the hydrogen is the positive *ion*, and the acid part is the negative *ion*. For instance, copper sulphate, $CuSo_4$, when dissolved in water, dissociates into the positive *metal ion* Cu, and the negative *acid ion*, SO_4.

An electric current is transmitted through an electrolyte by the motion of these ions. The metal or hydrogen (positive) ions travel in the direction of the current and carry positive electrical charges to the cathode, and these metal ions, called *cations*, are deposited upon or are liberated at the cathode. The acid (negative) ions travel against the current and carry negative charges to the anode, and these acid ions, called *anions*, will corrode the anode if it is a metal which combines chemically with these anions. The cathode is never corroded.

For instance, if the electrolyte is common salt dissolved in water, the anions are chlorine, and an iron anode would be corroded, the iron forming ferrous chloride; the cations are sodium, and these would decompose the water and liberate hydrogen at the cathode. With an electrolyte of copper sulphate dissolved in water, and a copper anode, the latter corrodes into copper sulphate and dissolves while metallic copper is deposited upon the cathode. These examples furnish an illustration of the fact that the corrosive action of the current results in supplying the electrolyte with an equivalent to the amount of salt decomposed by the current, so that the electrolyte is continually replenished with salt, and its electrolytic conducting power is thereby maintained. This salt will contain the metal ions of the anode, or hydrogen, and may be different from the original salt which started the action.

The rate at which the *ions* are liberated at the electrodes is proportional to the current strength. With an oxidizing anode, the mass of anode corroded by one ampere in one second is equal to the *electro-chemical equivalent* of the metal of

the anode. This is 0.00029 gramme for iron (ferrous). From this the mass of iron corroded by one ampere in one year is $0.00029 \times 60 \times 60 \times 24 \times 365$ grammes, or, $0.00029 \times 60 \times 60 \times 24 \times 365 \times 0.002205 = 20$ pounds (approximately). The electro-chemical equivalent for lead is 0.0010718, and the mass of lead corroded by one ampere-year is $0.0010718 \times 60 \times 60 \times 24 \times 365 \times .002205 = 74$ pounds (approximately).

The separating of the metal or hydrogen *ion* from the electrolyte at the cathode absorbs energy from the electric circuit and generally produces an electromotive force (e.m.f.) in the opposite direction to the current. The oxidation of the anode supplies energy to the circuit and generally produces an e.m.f. in the direction of the current. If an oxidizing anode is of the same metal as is being deposited upon the cathode, and the electrolyte is the same at the anode and cathode, there is no resultant e.m.f. due to the electro-chemical actions, and the only e.m.f. consumed is that due to the resistance of the electrolyte in accordance with Ohm's law, exactly as with a metallic conductor.

If the metal deposited at the cathode is different from that oxidized at the anode, or if hydrogen is liberated at the cathode, or if the electrolyte at the cathode is not of the same composition or density as at the anode, there will be a resultant e.m.f. which may be either in the same direction as the current or in the opposite direction to the current.

Street soils generally contain salts, principally chlorides, nitrates, and sulphates, dissolved in water, and this makes them *electrolytic conductors*. It has been claimed by some that soils conduct to a considerable extent metallically; this has however been disproved, and it is now understood that soils can only conduct electrolytically. The conductivity depends then entirely upon the chemical composition and wetness of the soil which vary greatly in different localities.

In practically all single trolley roads the trolley wire is connected to the positive pole of the dynamo, and the rails are connected to the negative pole. In cheaply constructed roads the connection to the rails is only made at the power station, and the rails are therefore expected to serve as the return conductor for all current. In order to make the rails

a continuous conductor they are bonded at their joints, ordinarily with copper wire.

We will now consider the result of this construction: The rails are in contact with the ground for their entire length, and as the street soil is a conductor, part of the return current must shunt through the ground in accordance with the law of divided circuits. This current, which, as it were, leaks from the rails through the ground, is called stray current. In the simple case under consideration (rails connected to the negative pole at station only) the potential of the rails increases with the distance from the station and with the number of cars in operation. Neglecting any slight counter electromotive force (c. e. m. f.,) the amount of stray current varies directly with the potential difference in the rails, and inversely with the resistance between the point at which the stray current leaves the rails and the point at which it again enters the return conductor. The stray currents would disappear then, either with zero potential difference in the rails, or, with an infinite resistance to their path, two conditions which are clearly impossible with a single trolley electric road, and therefore stray currents are always produced by such roads.

In some electric railway stations the negative busbar is grounded by means of earth plates. Since this diminishes the resistance to the ground, the result of this practice is to increase the stray currents.

If the ground through which the stray currents pass contains metals, such as water pipes and gas pipes, which have a high conductivity, these currents will largely pass through such metals. In general, in districts distant from the power house the stray currents flow through the intervening soil from the rails to the pipes; these districts are therefore called *negative* districts and the pipes in them *negative* pipes. In the district surrounding the power house the stray currents flow from the pipes through the intervening soil to the rails; these latter districts are therefore called *positive* districts and the pipes in them *positive* pipes. Between these two districts the stray current flows from rails to pipes or from pipes to rails, depending upon the distribution of the cars, etc. These intermediate districts are sometimes called *neutral* districts.

Since every electric circuit must be completely closed, all current which leaves the plus terminal of the dynamo must return to the negative terminal. For this reason all current which escapes from the rails in the negative district and reaches the pipes, must again leave the pipes in the positive district in order to return to the negative pole of the dynamo. The electric current is in this respect very different from gas or water, which latter can leak from a pipe and become diffused through the ground.

With the stray currents in the ground and on the pipes we have then the conditions of an electrolytic cell, the pipes and rails being the electrodes, and the dissolved salts in the soil the electrolyte.

In the negative district the current flows from the rails through the soil to the pipes, and the rails (anodes) are corroded, while the pipes (cathodes) are not corroded. The corrosion of the rails does not concern the pipe-owning companies, and they have considered these negative districts as *safe* districts.

In the positive district the current flows from the pipes to the soil, and the pipes (anodes) are corroded by the current. For this reason the positive district has been called the *danger* district.

The reason for connecting the *negative* rather than the positive pole to the rails was to concentrate the positive district within the region surrounding the power house; it was hoped in this way to restrict the pipes endangered by electrolysis to this definite and comparatively small region, so that they could be watched and remedies applied. It has been found, however, that there are many points in the negative and intermediate districts, for instance, at joints, where current may leave a pipe and produce electrolysis.

In most large single trolley systems the rails are connected to the negative busbars by return feeders at a number of places besides directly at the power station. At each point of connection of such a return feeder to the rails a positive region is established, and some stray currents will leave the pipes in this region to return to the rails near such points.

The danger region of a piping system is, in fact, by no

means confined to the so-called positive districts, but at every point where current leaves a pipe to pass into wet soil, electrolytic corrosion must take place.

An iron pipe is ordinarily not in uniform contact with the surrounding soil, owing to the high resistance oxide coatings, etc., so that the current leaves in spots where there is good contact with the soil. The result of this is that the corrosive action is concentrated at these spots so that holes or *pittings* are produced by the corrosion.

It has been stated that one ampere-year will corrode 20 pounds of iron or 74 pounds of lead. Secondary chemical reactions may, however, greatly increase this amount of corrosion. It must also be understood that this 20 or 74 pounds of corrosion occurs at every point at which the current leaves the pipe for wet ground, and that the same ampere of stray current can leave and again return to a pipe any number of times in its path, depending upon the electrical conditions; so that any number of times 20 or 74 pounds of corrosion may be produced by a single ampere of stray current in one year.

It has been shown that a small fraction of a volt (Jackson says "a mere directive force, in the nature of a pressure") will produce enough current to cause Electrolysis with the conditions generally present with underground pipes. This has been proven experimentally by a number of investigators, notably by Jackson,[1] Fleming[2] and Larson[3].

The published results of some laboratory tests with alternating currents seem to indicate that these may also produce Electrolysis, the extent of which is probably a small fraction of that produced by an equal direct current. Alternating currents would, however, corrode both electrodes. Electric trolley roads have only very recently begun to use alternating currents, and so far no practical experience has been furnished

[1] See "Corrosion of Iron Pipes," by Prof. D. C. Jackson, Journal of the Association of Engineering Societies, September, 1894.

[2] See "The Electrolytic Corrosion of Water and Gas Pipes by the Return Currents of Electric Tramways," by Dr. J. A. Fleming, The Electrician, London, Sept. 16, 1898.

[3] See "Electrolytic Action of Electric Currents Upon Iron Pipes in the Ground and the Resulting Polarization," by Prof. A. Larson, American Water Works Association Proceedings for 1903.

from which it can be concluded whether electrolytic corrosion is practically negligible or not. It is therefore not safe to assume, as some writers have done, that the substitution of alternating for direct currents on single trolley roads would eliminate electrolytic troubles.

It is clear from the foregoing that the electrolytic corrosion is produced where the current passes from a pipe to wet soil, and that the amount of corrosion depends upon the strength of the current and the time during which it acts. The fact that a pipe is positive to some other conductor is not in itself evidence that electrolysis is taking place ; there must in addition be an electrolytic conductor, in the nature of wet soil, between the pipe and the negative conductor, so that the potential difference can cause a current to flow from the pipe to the soil. The smallest quantity of a soluble salt in this soil is sufficient to start the corrosion, and this action of itself replenishes salt required for electrolytic condition as shown before. A high potential difference may even, under certain conditions, indicate a high resistance and a correspondingly small current with little corrosion, while a low potential difference may indicate a low resistance, and a large current with a correspondingly large amount of corrosion. Electrolytic surveys which consist only of voltmeter readings are, therefore, not sufficient to determine the existence and extent of electrolytic corrosion. Direction and strength of current flow in various parts of the system are required in addition to the voltage readings.

SECTION II.

ELECTROLYSIS IN AMERICA.

The corrosion and destruction of gas pipes, water pipes and and other underground metal, caused by stray currents from grounded railway circuits, has reached alarming proportions in many American cities. Much has been written on this subject during the past few years, and many remedies have been proposed and tried. In 1901 Mr. Edwin A. Fisher, City Engineer of Rochester, made an extensive electrolytic survey of the water pipes of Rochester in order to determine the extent of damage due to electrolysis, and to find what remedies

could be applied to prevent further destruction. The results of this investigation are published in the "Report of the City Engineer to the Commissioner of Public Works of the City of Rochester," under date of Aug. 1, 1901. This report also contains statements by the city engineers or superintendents of water works of twenty-five other cities in the United States, as well as the ordinances on this subject which were in force in several cities. Mr. Fisher's report is, in fact, an excellent resumé of the most important papers on electrolysis which had been previously published in this country. Your committee has not reproduced this report, and members are referred thereto for the information available at that time. In the present report your committee deals with the more recent developments in electrolytic conditions, and the following instances have been selected, from a large quantity of available matter, as best representing the present status of the electrolysis problem in America.

PEORIA, ILL.

This case is of peculiar interest, not only on account of the grave and specific character of the electrolytic damage sustained by the Peoria Water Works Co., but especially because litigation against the electric railway, begun in the United States Courts in 1898 by the receiver of the water company, has never yet been decided, notwithstanding the fact that the Special Master in Chancery, to whom the case was referred by the Court, after examination of some sixty-six witnesses extending over a period of three years, reported:

SPECIAL MASTER'S REPORT.

"*To the Honorable, the Judges of Said Court:*

"The undersigned, Special Master in Chancery, to whom by an order entered therein on the 26th day of May, 1898, the above entitled cause was referred to take evidence and report the same to the court, together with his conclusions thereon, respectfully reports:

"That said cause was set for hearing before the said Special Master for the purposes in said order specified at Peoria,

Illinois, on the 15th day of December, 1898; that adjournments were had from time to time and evidence taken at different times and places, as appears by the record thereof, which is made a part of this report and herewith returned into court; that having considered the pleadings in said cause and the evidence so taken, and having heard arguments of counsel, the said Special Master finds therefrom, as follows:

* * * * *

IX.

"In the months of May and June, 1894, an extended examination of the water pipe system then in possession of the aforesaid receiver, was made by electrical experts and more than one thousand electrical measurements taken, which showed that at that time there was in every instance a difference of potential, indicating flow of electric current, between rails and pipes. This difference of potential or electrical pressure was found to vary in different cases, from a fraction of a volt up to 45 volts. The measurements showed that in some places the flow of current was from the rails into the pipes, and in others from the pipes into the rails. Actual tests made at that time showed a loss of metal in single service pipes of over a pound of metal per month, the observations indicating that many other pipes were deteriorating at the same rate. Excavations were made in a number of places for the purpose of inspecting the pipes to ascertain their actual condition. Many of these pipes were found to be wasting away, and there was evidence that rapid electrolytic action was taking place.

X.

"On April 6, 1894, the receiver of the Peoria Water Company, who was in possession and operating the water works plant, caused notification to be made to the Central Railway Company: 'That the Peoria Water Company for a long time past has been and is now daily suffering and sustaining great injury and damage to its lead and iron pipes and other underground property in the streets and alleys of Peoria; that it is

put to great labor, expense and trouble in making and keeping up repairs on its said pipes by reason of the improper and unlawful use by you of the ground as a return conductor for electrical currents, and by the illegal, careless and improper use of electrical currents generally by you.' Similar notices were given to the Mayor and Common Council of the City of Peoria on or about November 24, 1893, December 8, 1893, December 19, 1893, January 2, 1894, and on February 7, 1898, which said notices called upon the city for protection under the water works ordinance against damages which the notices alleged were then being suffered.

XI.

"Another examination of the water piping system now owned and operated by the complainant, but then in the possession and custody of the said receiver, was made in the early part of 1898 by the same experts who made the examination in 1894. An electrical survey was made with a view to a comparison between the conditions existing in 1894 and 1898. The experts found and reported that the destruction was taking place more rapidly in 1898 than in 1894, and that it was being caused by electric currents generated by the defendants herein.

XII.

"During the progress of the taking of defendants' testimony in this case, it appeared from the evidence that some of complainant's iron gate boxes were located near the rails of defendants' track, and it was contended by defendants' counsel and experts that enough current was diverted by reason of the proximity of these gate boxes to account for all the electrolysis claimed by the complainant. It was contended by complainant and its experts that in no case did any actual contact exist between the gate box and the rail except in instances while a car was passing over the box. Nevertheless, thirty-five of these gate boxes were taken out and replaced by vitrified tile pipe, a non-conductor of electricity. In other cases the gate boxes were entirely removed and not replaced because not needed. This change left no gate boxes within

one foot from the rails. Examination and tests made by both parties after this change in the gate boxes showed large quantities of electric current from defendants' system still traveling upon complainant's pipes.

XIII.

"In June, 1899, and after considerable improvement had been made by the railway companies in the way of heavier rails and better bonding, and an improved return feeder system, another electrical survey was made of the existing conditions between the rails of the railway companies and the water mains of the complainant. This survey showed that a large volume of current was still flowing between the rails of the defendants and the pipes of the complainant, the voltmeter showing ten different readings of ten volts and over, the highest found being thirty-five volts, rails positive to pipes.

XIV.

"A difference in potential of a fraction of a volt will cause electrolysis and from the conditions herein above found and stated, the ultimate destruction of complainant's pipes by the currents of electricity allowed to escape from defendants' system is a question only of time and pressure.

XV.

"The evidence discloses no known method by which the complainant, by its own action, can protect its water distributing system of pipes and mains from the electric currents of the defendants' single trolley railways.

XVI.

"The evidence discloses no complete remedy for the injury to these water pipes except the entire removal of electric current from the water mains; such removal is impossible so long as the return current of the electric railways are grounded or in electrical contact with the earth. The other methods which have been suggested by the defendants in this

case do not, in practice, and cannot prevent the escape of a portion of the current into the ground and water pipes.

XVII.

"The defendants can prevent the injury by controlling the current generated as aforesaid, by means of the use of a complete metallic circuit, insulated from the rails and ground, providing a channel for the return of the current to the generator as perfect as the channel that is provided to supply the power along the street for use. In the District of Columbia, outside of the City of Washington, the double trolley has been and is being installed by a number of roads, under acts of Congress, providing, in substance, that where the overhead trolley is used it must be the double trolley, and also, that no portion of the electrical circuit shall, under any circumstances, be allowed to pass through the earth, and that neither pole of any dynamo furnishing power to the line shall be grounded. This action by Congress was caused by the interference of the electric current of the single trolley railways with underground metallic structures in Washington and the surrounding territory. The overhead double trolley system has been used in Cincinnati, Ohio, for ten years, and has been shown by experience during that time to be practical, economical and satisfactory, and the evidence shows that by its use in this case the return current might be carried back to the dynamos without coming in contact with the earth at all, and the difficulty from electrolysis thus be completely overcome. The original cost for installation of the double trolley system is considerably more than for the single trolley system. While the evidence in the record as to the exact cost of changing the defendants' system from the single to the double trolley is conflicting and unsatisfactory, it is sufficient to determine the fact that such cost would not be so unreasonable and excessive as to make it impossible for the defendants to adopt the double trolley system.

XVIII.

"The defendants' negative return system is as good or better than the average used by overhead single trolley electric

street railways in cities of the size of Peoria, and the defendants have done all that can be done under the present state of the art, so long as the single trolley is used, to care for the safe return of their electric currents; notwithstanding this, it clearly appears from the evidence that a portion of the returning current continues to escape to complainant's piping system and necessarily causes injury and ultimately destruction thereto.

XIX.

"At least twenty-five miles of complainant's water mains are laid under streets paved with permanent and expensive pavement and practically no access can be had to these mains except when made necessary by actual breaks in the pipes. The fact of injury to these mains in this territory from the electric current of defendants is capable of demonstration and has been demonstrated in this case, though it is impossible to determine the exact extent of the injury to the whole system at any given time.

XX.

"The ultimate facts disclosed by the evidence may be briefly summarized as follows:

1. The injury complained of exists.
2. The injury is permanent and continuing.
3. The injury has been and is being caused by the defendants.
4. The complainant can do nothing to prevent the injury.
5. The defendants can prevent it by use of the overhead double trolley system or by any system which provides a completely insulated metallic circuit for the electric current.
6. The overhead double trolley system, though more expensive to install, has been demonstrated by use and experience to be as safe, economical and satisfactory in its operation as the single trolley system.

Conclusion of Law.

I.

"The Court has jurisdiction over the subject-matter in this proceeding, because:

(a) The suit as originally instituted by the receiver was auxiliary to the main suit in which the receiver was appointed and was cognizable in the Circuit Court, regardless of the citizenship of the parties.

(b) When the receiver turned over possession of the property to the Peoria Water Works Company, as assignee of the purchasers, that corporation was properly substituted as complainant in the petition in place of the receiver, because it then had both the custody and title to the property and was a citizen of New Jersey, while the defendants were citizens of Illinois, and the cause of action remained the same.

II.

"The Court has jurisdiction over the parties to this proceeding, because the citizenship is sufficient, and the defendants, by coming into the Northern Division of the District and answering the petition filed there, without objecting to the jurisdiction over the person, have consented to be sued in that division of the district, and objection which might have been made on that ground is waived by consent.

III.

"In Illinois there is vested in municipal corporations the power of exclusive control over the streets, and in many cases a fee simple title to the streets; and under the power of exclusive control over the streets it is well settled by the decisions of the state courts that the municipal authorities may do anything with, or allow any use of streets, which is not incompatible with the ends for which they are established; and that use for the purpose of water pipes is among those for which the use of streets may be granted; and that the laying of water pipes under ground is much less of an obstruction and interference with the ordinary purposes of a street than the laying and maintaining of a railway track upon its surface.

IV.

"In view of the law of Illinois, relating to the use of streets, which has become a 'rule of property,' and therefore

will be followed by the Federal Courts, it cannot be held that the use of the streets for water pipes is in any sense subservient to the use for electric railway purposes, assuming that both uses have been granted by the municipality in the proper exercise of its authority.

V.

"Both parties to this suit acquired their rights in the streets by a grant under statutory authority from the City of Peoria by ordinance passed by the Common Council. Each occupies the streets by legal authority. Each is performing a duty to the public and each is compelled, under the ordinance of the city and the law, to serve the public. Each has money and property invested in its system and plant, a considerable portion of which, in each case, occupies the streets by such legal authority. Both are entitled to the equal protection of the laws against the invasion of their rights and property by others.

VI.

"The injury which is being done to complainant's water pipes by the defendants' currents of electricity is not a mere incidental injury or inconvenience, but is a permanent, continuing injury to a legal right, which will, in effect, if the injury is permitted to go on, ultimately result in the absolute destruction of complainant's plant and property. This would amount to nothing less than the taking away from complainant of the use of its property by the defendant street railway companies, which, if it be done under their license from the city, authorizing them to 'propel their cars by electric motor power,' would be a taking of private property for public use. The constitution of Illinois provides that 'private property shall not be taken or damaged for public use without just compensation.'

VII.

"The license from the City of Peoria to the defendants, while it grants the right to them to lay their tracks and 'propel their cars by electric motive power,' does not assume to give

the 'right' to so construct or operate their systems as to damage the property of others who have equal rights to the use and enjoyment of their own property. *A fortiori* this is true, because of the fact that it is possible for the defendants to so construct and operate their railways by electric motive power as not to interfere with or injure the water pipes of the complainant. But even if such license did not assume to grant the 'right' to operate in the manner in which the defendants are operating, regardless of injury to others, the law would not tolerate such use because of the provisions of the constitution above quoted.

VIII.

"The injury complained of in this case is the direct and immediate result of defendants' acts—as much so as if the defendants were to deliberately uncover and destroy by any other means the water pipes of complainant. The defendants, by taking the necessary reasonable precautions in operating their railways, would be able to avoid the injury, and this being true, their failure to take such precautions must be considered as negligence. It is as much the duty of the defendants, then, to refrain from injuring the property of the complainant by the one method as it is by the other. The complainant is as much entitled to protection against the injury from defendants' electric currents negligently allowed to stray upon its property, as it would be to protection from the wanton destruction of its property by any other direct means which might be employed by the defendants. The maxim, '*sic utere tue ut alienum non leadas*,' applies even under the strictest limitations of the rule which have ever been applied by the courts in any case.

IX.

"Although the defendants are operating their railways under ordinances from the city, granting them a license to propel cars by electric motive power and in so doing are interfering with the property and water pipes of complainant, such interference and injury is not *damnum absque injuria*, because:

1. It is possible for the defendants to so operate their railways by electric motive power as not to injure the complainant's property.

2. It is impossible by any known method for the complainant to protect its property from such injury.

3. Where there are two methods of accomplishing a legal result, and one method will work an injury to another, and the other method will not, it is the duty of the person doing the thing to use that method which will not result in injury to such other person.

4. The failure on the part of the defendants to observe such duty constitutes negligence, and when it results in damage to another, such damage is actionable.

X.

"The injury found to be going on in this case is the direct consequence of the unnecessary and wrongful acts of the defendants in accomplishing a legal result, that is, the propulsion of cars, and unless the defendants are protected by their license from the city, they are liable to the complainant for such injury. These acts, unnecessary and wrongful in themselves, are not rendered lawful by the ordinance granting the use of the streets for the purpose of propelling cars by electric motive power, and inasmuch as they work 'hurt, inconvenience and damage' to the complainant, they constitute a nuisance which is actionable at the suit of the injured party.

XI.

"The injury complained of being actionable, there can be no doubt of the power of the court to grant some remedy. The damage already done is chargeable to the defendants, and so far as such damage is capable of being definitely ascertained, the defendants should be held liable in a suit at law. But a suit and recovery at law would not stop the injury, which is, and must necessarily be, continuous under existing conditions. The very life of complainant's plant and franchise is threatened. The only adequate remedy is, therefore, by injunction, as prayed in the petition.

"The special master's conclusion is that the bill and evidence make a case of equitable jurisdiction and that an injunction should issue as prayed, subject to such reasonable conditions as to the court may seem right."

(Signed) FRANK L. WEAN,
Special Master in Chancery in Said Cause.

CHICAGO, April 30, 1901.

Descriptions of some of the electrolytic damage already sustained by the Peoria Water Works Co. up to that time are giving in an interesting paper read before the American Water Works Association, in May, 1900, by Mr. Dabney H. Maury. "Engineering News" of July 19, 1900, contains a condensed reprint of this paper—in part, as follows:

"On March 30, 1894, the water company's steel stand-pipe on the West Bluff burst, killing one person and injuring fifteen others, one of whom died later from his injuries. Upon examining the wreck of the stand-pipe, the writer at once noticed a peculiar pitting of the inside of the vertical sheets, and the appearance of these pits was so different from that caused by any ordinary oxidation that he was soon almost positive that they were due to electrolytic action. A similar stand-pipe on the East Bluff was drained, and was found to be similarly pitted. The whole inner surface of the vertical shell appeared to be thickly covered with blisters resembling in outward appearance the tubercles sometimes found inside of old cast-iron mains. This blistered covering, which was almost as thin as paper, was composed entirely of oxide of iron, and on brushing it away with the finger tips, the black paint with which the stand-pipe had been originally coated would be found beneath it. The black paint was oftentimes almost unbroken, or, at least, very slightly cracked. When the paint was brushed off, the pit would be disclosed, considerably smaller in area than the surface covered by the blister. The surface of the metal in the pit was perfectly bright and clean and its fiber was clearly discernible. Many of these pits were more than ⅛ inch in depth. They were slightly more numerous in the West Bluff pipe than in

the East Bluff stand-pipe and were in both generally larger and deeper on the lower courses of the vertical shell.

* * * * *

"In 1899, a series of tests were made by Mr. A. A. Knudson, in conjunction with the writer, at the site of the fallen West Bluff stand-pipe, in order to still further prove that when that stand-pipe was in service, there was an actual flow of current in the manner already shown by the previous tests at the East Bluff stand-pipe by Messrs. Stone & Webster. The anchor bolts were still in the foundations, but the shell of the stand-pipe, as well as the 16-inch inlet pipe leading thereto, had been removed. It was necessary, therefore, in order to reproduce, to some extent, the actual electrical conditions that had previously existed, to connect a wire from the ends of the anchor bolts to the 16-in. water main in front of the stand-pipe. By connecting in a voltmeter on this wire, the variations of potential between anchor bolts and the water main were observed, and by replacing the voltmeter by an ammeter, the actual flow of current was measured. This current was clearly and positively identified as caused by the street railways, and the result of these tests fully confirmed the statement in the reports of Messrs. Stone & Webster, that the pits in the shell of the stand-pipes had been caused by the street railway current.

"The joints of cast-iron water mains often offer, as already stated, considerable resistance to the passage of the electric current, and the reason for this resistance is apparent, when the construction of these joints is studied. Cast-iron water pipes are coated inside and outside with a preparation of coal tar that is an insulating material. In making a lead joint, the spigot end of one pipe is inserted in the bell end of another pipe and pressed home until it touches the shoulder in the bell. The spigot pipe is centered carefully, so that the annular space designed to hold the yarn and lead may be of equal width all around. The yarn is then rammed in home against the shoulder, and holds the spigot in the center of the bell. There can thus be no actual contact between the two pipes, except where the very end of the spigot abuts against the shoulder of

the bell. As both spigot ends and shoulder are simply rough castings and are not turned, it follows that they are rarely in mechanical contact at more than two points, and on curves they can only touch at one point. In fact, it is frequently true that after the spigot pipe is once shoved home against the shoulder of the bell, and then released, it works away in the subsequently handling and yarning, and oftentimes is not in contact with the bell at all. Even if the two pipes were in actual mechanical contact, the electrical contact would be poor, by reason of the two intervening coatings of tar or asphalt. In that portion of the joint occupied by the yarn, there is no contact between the two pipes, and they are at this point fairly well insulated by the yarn itself, as well as by the two coatings. The rest of the joint is filled with lead, which is a conductor of electricity, but in between the ring of lead, and the bell outside of the lead and between the lead and the spigot on the inside, are the two tar coatings which materially interfere with the electrical contact between the two pipes.

"As it had been stated that the tar coating is completely consumed and burnt out by the heat of the molten lead when a joint is poured, the writer caused a joint to be poured and calked in the usual manner, and then had the bell sawed into three pieces, so that it could be taken off the spigot. It is needless to tell men who have had experience in laying and taking up water mains, that the inner surface of the bell showed that the coating was entirely unimpaired by the heat.

"Measurements were made by the writer in 1898, to determine the amount of resistance offered by the joints in cast-iron water pipes, and also to ascertain whether the pipes themselves showed any pitting as a result of this resistance.

"A large number of these examinations were made during 1898 and 1899, and in every case the pipe which was of the higher potential, was found pitted near the joint, while the pipe of lower potential, or that into which the current was flowing from the other pipe, showed much less electrolytic injury.

"To further test the joint resistance and to determine, if possible, the influence of different methods of calking as affecting this resistance, the writer, in conjunction with

Professor Jackson, caused a line of 6 and 4 inch pipe to be laid and supported on wooden blocks, so as to insulate it from the ground. There were 27 joints in all. The pipe was new and had not been previously used. The calker was instructed to drive up the lead hard in one-third of the joints and to calk these joints in every way in the best possible manner, just as though the pipes were expected to stand the heavy pressure of the Peoria Water Works Co.'s system. Another third of the joints were calked not quite so hard, while the remainder were purposely only lightly driven up, the work being done as though carelessly, or by a bungler. A current of known strength was passed through the pipes, and the drop of potential around the joints was measured at points 1 ft. apart, and was compared with the drop of potential in lengths of 1 ft. of continuous pipe. These measurements were made at different times; first by Professor Jackson and the writer; then by the writer alone, and later by Mr. Knudson and the writer. The resistance of the joint was found, as shown by the table [not reproduced here], to be from a few times to several thousand times that of the same length of continuous pipe, and this joint resistance was in no way affected by the manner in which the lead was driven up in the joint, some of the joints on which the best calking was done showing the highest resistance. The usual depth of lead in a joint in a cast-iron pipe is about 2½ in., but assuming the length of the joint at 4 in., the joints in this line offered 89.2 per cent, of the total resistance of the whole line, or on the average the resistance of a joint was 227 times the resistance of 4 in. of plain pipe. In making this calculation, due allowance has been made for the fact that the points of measurement around the joint were 1 ft. and not 4 in. apart.

"These observations, taken over a period of about eleven months, also showed that the resistance of the joints increased rapidly with age.

* * * * *

"The injury caused by resistance at the joints is not so rapid at any one spot as the injury where the current leaves the pipe for the rails in the positive area, only because all of

the current carried by the pipe does not flow around the joint. But one ampere of current, leaving the pipe for the power-house in the positive area, pits the pipe but once at that point; while one ampere of current, flowing along the pipe and around joints in either the positive or negative district, pits each length of pipe near every joint, where it leaves it to flow around the joint; so that the total injury caused by this ampere is cumulative, and may be, in the aggregate, hundreds of times as great as the damage caused by the same ampere of current where it permanently leaves the pipe.

"The effect of the current on the rail joints of a single trolley system is similar to that on the joints in the water mains. Within the past three years the writer has examined many hundreds of rail joints, and it was always easy to tell from the appearance of the rail ends, and of the chairs, when the rails were laid on chairs, which way the current was flowing. The end of that rail which was next to the power station would show little or no injury, while the end of the other rail, or that having the higher potential, was invariably pitted.

* * * * *

"The soil around the outside of a water main offering an easier path for a current than the water or slime on the inside, outside pittings are more numerous and generally deeper, and they are much more easily observed.

"The pits on the outside may be caused either by current which leaves one length of pipe to go around a joint into the next length of pipe; or by current permanently leaving the main for some other conductor of lower potential, such as rails, or wires leading to the dynamo; but the inside pits can not be caused by anything except resistance in the line of pipes itself at the joints, as nothing else could make the current leave the metal of the pipe and travel through the water.

"Opportunities for observing these pits have heretofore been rare, as the action is naturally slower inside the pipe than outside, and as it is necessary for some one familiar with the effect of electrolysis to be present and actually examine the

pipe at the time when it is removed in order that the pits may be identified.

"The pittings in the 16-in. inlet pipe to the West Bluff stand-pipe, observed in March, 1894, and inside pittings found by the writer in a 20-in. cast iron main in 1896, are believed to be the earliest examples of this injury noted, but numerous instances have since been reported.

* * * * *

"Mr. A. A. Knudson found deep outside and inside pittings in Albany in 1899.

"Professor Blake, from recent examinations in Kansas City, writes as follows: 'A 12-in. pipe running at right angles to an electric railway, and which was negative to the rails, was found to be carrying a current of varying strength and delivering it into a 36-in. main some 750 ft. distant.

"Electrolytic pittings were found on many sections near the joints, only on the positive side, where the current was shunted around the joints. Some of the pittings were ½-in. deep. The interior of the pipe could not be examined.

"Again, a length of 6-in. cast iron main was taken up in another part of the city, and internal electrolytic effects were apparent near the joint. A chemical analysis of the material dug from the pits gave 22.3 per cent. graphite, 49.7 per cent. iron.

"A second length was removed and broken into, and a fresh fracture revealed the internal electrolysis by the discoloration of the iron where the pitting was taking place, and which was already ¼-in. deep, beginning from the inside. A number of similar cases were discovered, and are convincing proof that cast-iron mains cannot convey currents without electrolytic damage, when those mains form part of the return circuits of electric railways.'

"Within the past few months the writer had occasion to remove from the ground a 16-in. cast-iron main. This main was negative to the rails, and was nearly two miles from the power station. It lay at right angles to the tracks, and the portion removed was distant, at its nearest point, about 150 ft. from the rails, and at its further end, 570 ft. from the rails,

there being 420 ft. of pipe removed. Measurements with voltmeter and ammeter showed a current flowing along this pipe from the rails towards the wet soil of the river bank, in which the further end of the pipe was buried. Every length of pipe showed electrolytic injury. In one pipe the bead in the spigot end had been eaten off for two-thirds of the circumference of the pipe, and in one place the entire thickness of the pipe was eaten out for nearly an inch in depth from the end. There were both outside and inside joint pittings, always on the positive side of the joint, and no pits at all could be found anywhere else on this pipe.

"In a recent paper, Professor Blake states that observations and experiments prove that the effects of electrolysis upon water pipes are not limited to the so-called 'danger areas' or districts in which the pipes are electrically positive to the rails. He goes on to say: 'Resistance at the joints in cast-iron pipe is sufficient at most joints to shunt a portion of any current allowed in these mains, around the joints through the soil outside or water inside, or through both. Then, on the positive side of joints, the effects of electrolysis, both external and internal, are to be apprehended.'

* * * * *

"Street railway companies have frequently recommended that the pipes themselves be connected by wires to the negative busbar of the generator, or to the rails at various points, or to overhead or underground return feeder wires — thus diminishing the resistance of the pipe system as a conductor, and lowering the potential of the pipes usually in what has been termed the 'danger district' or the region where the pipes are shown by voltmeter to be positive to the rails. * * *

This would apparently lessen the rapidity of injury to the pipes in the 'danger district,' and, by stopping temporarily the number of actual breaks at the points where they have been occurring with greatest frequency, it would stave off the day of reckoning with the pipe owners. But the general pipe system would be carrying much more current, and, as the pitting goes on, at or near the joints, wherever a main is carrying current, either in the positive or negative district, it

would mean that, while the injury in the 'danger district' would not be so rapid, the whole system would be much more generally attacked, and that by the time a bursting pipe at length called attention to the injury at some point remote from the power station, the entire pipe system would have been seriously injured.

Equally impracticable and misleading are the suggestions for maintaining the pipe system at equal potential throughout, and for 'insulating sections' or 'insulating joints', some of which have been patented.

* * * * *

"'What, then, can be done to entirely remove the cause of the injury? The answer is simple. Keep the return currents out of the ground.

"'This has been successfully accomplished in this country for years by two methods. In Cincinnati, and in Washington, D. C., the double overhead trolley is in use, while New York and Washington have been the first to adopt the conduit system.

* * * * *

Both the overhead and underground systems have proven successful in practice, not only in entirely preventing electrolysis, but in what is naturally of far more importance to the street car companies, in the general economical details of operation and maintenance. The conduit system is, of course, more expensive to build, and is peculiarly adapted to the larger cities.

"'The Cincinnati overhead double trolley system comprises about 220 miles of track. The conditions of its operation are unusually trying, among them being narrow streets, grades sometimes as high as 12½ per cent., and, in places, especially near Government Square, a multiplicity of intersecting tracks such as is, perhaps, not equalled in street railway construction anywhere else in this country. Every car on the system, at some time in its regular trip, must pass over one of the tracks at Government Square, and to stand during the busy hours and watch the perfect ease and smoothness with which the hundreds of cars thread this maze of

tracks, at times at intervals of only four or five seconds, will convince even a skeptic of the mechanical practicability and success of the double overhead trolley.

* * * * *

"The double trolley is safer than the single and the difference in appearance between them is trifling. All connections are in plain sight overhead, and are always accessible for repairs. No lightning arresters are needed. No excavation of street or pavement is required to renew rail bonds, as the rail bonds themselves are no longer needed; while for hill climbing, in bad weather, the double trolley is far more efficient, since both rails may be sanded, while in the single-trolley system, one rail must be kept clean, in order to keep electric contact between wheel and rail, thus diminishing the the fractional grip of the wheel on that rail, while the sanded rail is, at the same time, nearly useless as a conductor.

"In Washington, D. C., all roads within the city limits are required by law to have a complete insulated underground metallic return for their current, and by recent acts of Congress, passed on account of electrolytic injury caused by the single trolley systems, the overhead double trolley is required in all other new or amended charters, within the District of Columbia."

Taunton, Mass.

The results of an electrolytic survey of the water pipes of Taunton, made in 1901, by Mr. A. A. Knudson, are published in the "Annual Report of the Water Commissioners of the City of Taunton" for 1901. The following are extracts from "Conclusions and Recommendations:"

* * * * *

"Third.—While it is of the utmost importance to have a rail return in its most efficient state as a conductor, so as to prevent excessive amounts of current straying to water mains, there is no certainty of such rail return remaining efficient for any length of time, and, consequently, so long as such

system is used so long will there be danger of damage by Electrolysis to water piping property.

"The only sure remedy against such damage, therefore, is for the railway companies to abandon the rails entirely as a conductor, which are most unreliable as such, and adopt the double trolley system. * * *

"FOURTH—The conditions found at Oakland seem to call for special attention. The 1,700 ft. of 6-in. pipe in Tremont street, or that portion lying between Walker street and the 'dead end' is, as we have endeavored to set forth, been practically ruined by electrolysis. The prime cause is traced to the inefficient rail return of the Taunton and Norton Railway."

In 1902 a conference was held between the Superintendent of the Water Works, Mr. A. A. Knudson, and representatives of the electric roads of Taunton, regarding electrolysis. The following extracts from Mr. Knudson's account of this conference are taken from the Water Commissioners' Report for 1902:

* * * * *

"While I am satisfied that the result of this conference will be beneficial, in emphasizing as it did, the importance of maintaining as perfect track returns as possible, it should not be considered in any way as a final solution to this question of electrolysis; and no action should be taken upon your part or on the part of your Honorable Board tending to relieve the railway companies operating their lines in your city from responsibility for damage which may be discovered to water mains in future.

"In this connection attention may again be called to the unbounded tracks on Tremont street which are 'grounded' in the river under the bridge on that street. This is a condition favorable for trolley current to pass to your main in that street, and is, we believe, largely the cause of damage found upon the main in Oakland.

* * * * *

"There is another feature in the peculiar movements of trolley currents which may be mentioned here, viz.: The

passing of current from one main in the soil to another, which may be in the same street, a few feet distant. Recent examinations by the writer disclosed damage by electrolysis to mains where no voltmeter tests upon the surface would indicate such action, and consequently such conditions are very difficult to locate."

DAYTON, OHIO.

The following statements in regard to the electrolytic situation in 1901 are taken from the "Annual Report of the Dayton Water Works" for 1901:

ELECTROLYSIS.

"The escaping current from the various electric railroads continues to damage and destroy the main lines of pipes, and services, as mentioned in the previous Annual Reports. This Board has not been inactive in its efforts to have the same removed and the city compensated for the damage. Your attention has been called to this matter from time to time since 1894, when the first indications of electrolysis began to manifest itself.

* * * * *

"The fears expressed by this Board to your honorable body several years ago as to the outcome of this trouble are now being fully realized, and while we know of a great amount of damage done, it will be impossible to get at the full extent, without exposing the pipes, which would entail an enormous expense.

"On November 15, 1899, mandatory injunction suits were entered against the City Railway Company, The Oakwood Street Railway Company, The People's Company, and The Miami Valley Traction Company, praying for injunction requiring such method of traction or devices to be used as will take and keep the current off the water pipes.

THE FIRST CASE (NO. 20,763).

"The City of Dayton, Plaintiff, *vs*. City Railway Company, Defendant.

"The trial of this case began October 14, 1901, and lasted about eight weeks, and at the close of the testimony the court fixed the week beginning January 13, 1902, as the time for argument."

The decision in this case was rendered in time to be included in the same Annual Report, and is as follows:

COURT OF COMMON PLEAS, MONTGOMERY COUNTY, OHIO.

(NO. 20,673.)

The City of Dayton,
Plaintiff,
vs.
The City Railway Company,
Defendant.

Opinion of the Court,
April 5, 1902.
O. B. Brown, Judge.

* * * * *

SUMMARY OF FINDINGS.

"Upon consideration of the entire matter, I have come to the following summary of conclusions as to the law and facts:

"This Court has no authority in law to compel a change in the system from the single trolley to the double trolley, and, if the same were warranted by the law, the facts would not justify such a change.

"The defendant has been, and is operating its road in a negligent manner, causing continual damage to the water pipes of the plaintiff, for which the plaintiff has no adequate remedy at law, and cannot by any practical method prevent such damage.

"It is no excuse in law, and the facts would not justify the defense that other electric lines in Dayton are contributing to this or doing like damage.

Spelling, Sections 390-397.
McClung *vs.* North Bend Coke Co., 9 C. C., 259.
Meigs *vs.* Lister, 23 N. J. Eq., 199.

"It is therefore the duty of the Court to enjoin the defendant from so operating its railway and to compel it, within a reasonable time, to introduce such improvements in

the system, in order that the operation of the single trolley system, authorized by the franchise and contract, will be in accordance with the present standard of the art of operating single trolley roads. The plaintiff shall co-operate to that end.

"All matters of detail can be arranged between counsel and the Court in the final order.

"The costs will be adjudged against the defendant."

Considering that this trial lasted eight weeks, during which time some ninety-two witnesses were examined, the above decision cannot be characterized as other than a masterpiece of indecision.

The following open letter giving later experiences with electrolysis in Dayton was published in the Railroad Gazette of Jan. 5, 1906:

DAYTON, OHIO, Dec. 26, 1905.

"*To the Editor of the Railroad Gazette:*

"* * * If the officials of the cities affected by this growing evil [Electrolysis] were to make public the vast amount of information which is now available, there would be few places having municipal water plants where the single trolley system has been in use for any considerable length of time, that could not report more or less damage to the pipes, due to the escape of electricity used in the operation of street railways. The City of Dayton, where I am Superintendent of the Department of Water, was one of the first cities—if not the first—in the United States to take up this difficulty with a traction company as soon as it was positively known that the escaping current from the street railway lines was destroying the pipes belonging to the city. The first official action in this matter was in 1898, when reports were made to the Water Board in July of that year, although the damage to the pipes at that time was not sufficiently pronounced to cause alarm to those in charge of the Water Works Department. Up to that time none of the main lines had burst, due to deterioration by Electrolysis, although a number of service branches had already given way and naturally had raised a question of how long it would be before it would be shown that the escaping electric current had weakened the

main lines sufficiently to cause them to burst. The great damage to the city mains in the interim has proven that the loss is, if anything, greater than anticipated. Within the last ninety days the city has been obliged to abandon or remove as junk about 1,600 ft. of main line pipe on one street alone, which has been destroyed by the electrolytic action of the street railway current. To avoid excavating under the car tracks in the future, when it may again be necessary to make repairs, there has been placed a line of pipe on each side of the street, with short service connections to the curb. These two lines of pipe were not laid with the idea of overcoming the electrolytic difficulty, for the conditions so far as current is concerned have not been preceptibly changed, so that the pipe which has just been put in will in time go through the same course of destruction as the line which was abandoned. Those in charge of municipal water works and who might be required to make such a change as above mentioned on paved streets, can form some idea of the expense involved and of the annoyance and inconvenience to the public. There seems to be no possible way in which the pipe system can be so insulated where direct current is used as to sufficiently control the current to prevent Electrolysis, although many devices have been bought and put into use, such as additional bonding, auxiliary wires placed adjacent to the street car rails, and the rails themselves cross bonded and additional overhead return feeders, which expedients have not had the desired effect. The accompanying photographs [not reproduced here] show the destructive electrolytic effects experienced at Dayton."

(Signed) CHAS. E. ROWE,
Superintendent, Department of Water, Dayton, Ohio.

RICHMOND, VA.

The following report of an electrolytic survey of the water pipes of the City of Richmond, made by Mr. Dabney H. Maury in 1903, is published in a "Special Report of the Water Committee," dated May 2, 1904. The tables and maps are not reproduced:

PEORIA, ILL., Aug. 21, 1903.

"*The Honorable Committee on Water, Richmond, Va.:*

"GENTLEMEN: Having, at your request, examined the water-mains in Richmond to determine, as far as practicable, the extent to which they have already been damaged by Electrolysis, and to make recommendations for the prevention of further injury, I respectfully submit, as follows, my report:

VOLTMETER READINGS.

"At about sixty places, distributed over the city, the difference of potential between water-mains and the rails of nearest car track was measured, and the readings are shown by the figures in red or black, on the accompanying map of the pipe system, furnished me by you [not reproduced here].

* * * * *

"The general results of all these readings would indicate the following conditions:

1. "The differences of potential between mains and rails are, as a rule, unusually low compared with those in other cities. Most of the maximum positive readings are less than one volt, though several were found exceeding two volts, and one as high as four and seven-tenths (4.7) volts.

"The small average difference of potential between mains and rails indicates a low soil resistance, as well as a better system of return conductors and feeders than is usually found.

"The soil in Richmond is clay, either wholly or in part, no pure sandy soil being found by me in any excavation. The clay is nearly always moist, and wet clay has, as compared with dry and sandy soils, a very low resistance.

2. "The points at which mains are either normally, or at intervals, positive to rails, are by no means confined to the regions near the power station, or near the return feeder taps leading thereto from the rails, but are found at long distances in every direction, and sometimes several miles away.

3. "It is evident that the local street railway companies have of late been very diligent in improving the rail bonds and return feeders, presumably not only to provide a better

and more economical return for their current to the power station, but also in the hope of reducing, as far as might be possible by this method, the difference of potential between mains and rails, and the injury to the former by Electrolysis. A comparison of the voltmeter readings taken by me with those recorded by Mr. A. M. Schoen, in his report to you made several years ago, shows that the differences of potential are now, as a rule, considerably smaller than those then existing.

4. "The improvement of the return conductor system of the local street railways has, except on a few tracks, which are principally in outlying districts, progressed so far that the practical limit of the benefit to pipes that might be expected therefrom has been almost attained, and the betterment in electrolytic conditions that would result from additional return feeders, even if these were much larger and more expensive than those now in use, and from still greater improvement in rail bonding, would be comparatively small.

5. "Nevertheless, the existing conditions are serious, and as shown by the actual examinations of the water mains, the total amount of injury already suffered is very great, and this injury is continually increasing in amount.

EXAMINATION OF MAINS.

"In order that I might inspect your mains, excavations were made at fifty different locations, distributed all over the city. As these excavations were often made at intersections of two or more lines of mains, they resulted in exposing, at each location, portions of from one to seven different lines of mains, so that at the fifty locations I was able to see portions of a total of 101 different lines of mains.

"In every instance the mains were found to be carrying some street railway current. The quantity of current on single mains varied, according to the location, from very small fractions of an ampere to eighteen amperes.

"In every instance, the outside of the pipe showed evidences of electrolytic injury, rarely very slight, and often very serious.

"As it would have been necessary to cut the pipe apart in order to inspect the inside of the joints, no examination was made of this part of any main.

"However, the prevalence of pittings on the outside of mains on the positive side of joints, in districts where mains were normally negative to the earth ; the redeposited compounds of lead in the soil in front of the joints, and several leaks found in the joints themselves, furnished abundant evidence that joint pitting, inside as well as outside, is going on all over the system as a result of the shunting of a portion of the street railway current around the joints, both inside and outside the pipe. A number of measurements were made of the electrical resistance of the joints of your water mains, and the joint resistance was found to vary from a few times to many thousands times that of the resistance of a length of the plain body of the pipe equal to the length of the joint.

"As striking proof of the fact that the injury to your mains is still going on, I may mention the fact that pipes laid within the last two years were found to be seriously affected, and well-defined pittings were found on an 8-inch main, which, as I am informed by your Superintendent, Mr. Charles E. Bolling, had been laid only about six weeks before I examined it.

ESTIMATE OF DEPRECIATION.

"Attached hereto will be found a small blue print, entitled 'Estimate of Cost Per Lineal Foot of Mains of Richmond Water Works Before Pavement Was Laid' [not reproduced here].

"I consider that the prices therein given are fair average prices for the cost per lineal foot of pipe for the period during which your mains were laid, assuming economical work and ordinarily favorable conditions.

"A tabulated statement, embodied in the attached larger blue prints, entitled 'Depreciation Due to Electrolysis on Mains of Richmond Water Works,' 'Sheet 1,' 'Sheet 2,' 'Sheet 3,' and 'Sheet 4,' shows the length and size of mains, on each street, the original cost per lineal foot for each size of main, the estimated per cent. of depreciation of each main, and

the consequent depreciation based only on the original cost of the mains.

"In this tabulated statement, the per cent. of depreciation of each length of pipe examined is based upon the relation which the depth of the deepest pits found in each case bears to the actual thickness of the pipe.

"The estimate of depreciation on lines of mains not actually examined is based on the depths of pittings actually found in pipes nearest to such lines, due regard being had to the electrolytic and other conditions in each case. While it is admitted that in individual cases the estimated percentage may be too large, it is equally true that in other cases it will be found too small, and it is my opinion that the average percentage of depreciation, due to outside pittings only, is as fair as could be arrived at from the number of actual examinations made, and that additional examinations would result in confirming its reasonableness.

"The total estimated first cost of the mains alone is $766,974, and the total estimated depreciation of these mains, based on outside pittings only, is $170,224, showing an average depreciation of 22.2 per cent. from this cause.

"These figures by no means cover the total damage caused by Electrolysis, as they include no allowance for any of the following items:

1. "*The Additional Cost of Repairing Leaks or Breaks in Pipes.* When your pipes were first laid, they were laid in long stretches, and under favorable conditions for economical work, without expense for repaving, and with comparatively little interruption due to traffic on the streets. As the pipes break, they must be renewed piecemeal, and under far more disadvantageous conditions. The streets are usually paved, traffic is more congested, leaks are hard to locate, especially under pavements, the water has to be shut off, and extra specials or fittings are always required to repair the break.

"These facts make the cost per lineal foot for repairs several times greater than the first cost of the pipes.

2. "*Depreciation of Service Pipes.* These were, except in a few instances where they happened to be exposed in the excavations, not examined by me. I am informed by your

Superintendent, Mr. C. E. Bolling, that you have about 15,000 extra strong lead services, and that over 200 of these have already actually burst from Electrolysis. The estimate does not include any allowance for depreciation on 3,934 feet of 1½ in. pipe, which may be classed as service pipe. As this 1½ in. pipe and the service pipes are much thinner than the cast-iron mains, their percentage of depreciation is considerably greater than that of the mains.

3. "*Pittings on Inside of Joints.* The injury to the mains, by reason of pittings on the inside of the joints could not be examined. This injury, while usually slower than the outside pittings, is unquestionably serious in amount, and is continually increasing all over the system.

4. "*Cost of Repairs.* The cost already incurred in repairing leaks and breaks due to Electrolysis in mains and service pipes, which has, I am informed, been charged to the local street railway companies, and paid by them.

5. "*Incidental Damages Due to Breaks in Mains.* Under this head may be included the loss of water, the destruction of pavements and of car tracks, the settling of foundations of buildings and the flooding of basements, and damage to the goods stored therein by the escaping water, cutting off of the water supply and fire protection from the territory affected, and the risk to lives and property of citizens as a result of any conflagration that might take place before the break could be repaired.

"The amount of added damages due to all these causes cannot, from the nature of the case, be expressed in figures. It is evident, however, that the estimate of $170,224 for depreciation due solely to outside pittings on mains, would have to be very largely increased in order to cover the total actual damage.

REMEDY AND CONCLUSIONS.

"At its annual meeting in 1900, the American Water Works Association appointed a Special Committee on Electrolysis 'to make recommendations for the guidance of the Association in dealing with the problem, and to formulate for the approval of the Association an expression of the attitude

of the Association on this question.' The report of this committee was published in 1900 in the Transactions, so that all the members might have an opportunity to carefully read the report before voting on it at the next annual meeting in 1901. At that meeting the report was unanimously adopted, and the resolutions were unanimously passed, as an official expression of the attitude of the American Water Works Association on the question of Electrolysis.

"'The report in full is as follows:

[Mr. Maury includes this report here; it will be found under separate heading at the end of this Section].

"Every examination that I have made of piping systems since the above report [to the American Water Works Association] was published, has served only to strengthen my conviction of the truth of all the statements contained in the report, and of the wisdom and propriety of the resolutions embodied therein.

"The adoption of a properly constructed and maintained conduit system or double trolley system will absolutely prevent further injury to your pipes, and this result can be attained by no other known practical method.

"It is my opinion that to make the change from the single to the overhead double trolley system would be the very best business policy for the street railway companies.

"I therefore recommend that your honorable committee adopt such reasonable measures as may result in securing the change from the single to the double trolley system in the shortest possible time."

Respectfully yours,

(Signed) DABNEY H. MAURY,

Consulting Engineer.

Following the above report, the Water Committee and the Street Railway Companies agreed,

"That the matters now in dispute between the City of Richmond and the Richmond Traction Company, and the Richmond Passenger and Power Company, in its own right and as successor of certain other lines of street railway formerly operated on the streets of the City of Richmond by

other street railway companies relative to the amount of damages now due and unpaid to the City of Richmond by said companies by reason of the destruction or injury to the water-mains and pipes of the City of Richmond by Electrolysis, be, and the same shall be, submitted to the award and final arbitratament of five arbitrators as provided for in the articles of agreement to be executed as hereinafter provided."

The bankruptcy of the street railways, however, has prevented any action under this agreement up to the present time.

New Bedford, Mass.

The following is taken from the results of two electrolytic surveys of the water pipes of New Bedford by Mr. A. A. Knudson, published in the "Annual Report of the Water Board" for 1903:

SUMMARY OF PRELIMINARY REPORT NO. I.

1. "The tests and examinations at points G and E result in finding a current of an average of 5 amperes flowing north on the force main between these points and led off from the main to the tracks of the railway by the 2 in. service pipe, which accounts for this pipe being frequently destroyed at this place. While this amount of current is comparatively small, it is quite sufficient to cause the damage it has.

2. "Tests and other examinations indicate that this small current flowing north between G and E is only a remnant, in other words, only a portion which slips past the crossing at Beaver Dam. The main part, we believe, goes by way of the Reservoir, when cars are south of Beaver Dam, and the most of it passing out of the main at some point not yet discovered west of the crossing.

"* * * * * Mr. Goff's letter of May 18, 1903, puts the matter concisely from the railway point of view: 'Our electrical department recommends that the track be bonded to the water pipe at Whitestone Brook and a distance of several thousand feet beyond.'

"* * * * * I cannot too strongly endorse the position

which you have taken. One extract quoted from your letter of May 19th covers this position: 'In my opinion, the City of New Bedford will not be at all content for you to prevent further Electrolysis by making our water pipes a direct medium for the conveyance of your return current.'

"It is not unusual for railway companies to advise this method, it being the least expensive of any for avoiding the trouble, but such a scheme as converting your force main, a splendid steel structure, into a medium for returning railway current, should not be seriously considered for a moment. * * * *

"The complete remedy is an insulated return, or better known as the double trolley; in such a system there is no connection with the rails or earth, and consequently there is no current passing to underground mains. Methods for mitigating the evil may be advanced by the railway people, such as a system of supplementary track feeders over the entire line and rebonding tracks. Unless such a method were very carefully and well constructed, it is doubtful if such a plan could give the assurance of permanent safety.

"In any event the bonding of this main to the rails should not receive consideration for the reasons stated."

REPORT NO. 2—COMPLETED.

* * * * *

"Upon examination it was found that several lengths of pipes were badly softened by Electrolysis at the spigot end as shown.

"The worst damage was found a little back of the joints, where nails can be seen driven in the soft material. The joints were the ball and socket pattern. The pittings and furrows were from ⅛ in. to ⅜ in. depth. The three lengths when seen by the Superintendent were condemned as unfit for further use owing to their weakened condition. There were other pittings upon these lengths, but the greater damage seemed to be concentrated at the spigot ends, the result without doubt of railway current passing through the pipe in the direction from spigot to bell.

Summary and Conclusions.

"* * * * The connection spoken of between the condenser pipes and switch board at the power house is an indirect connection between the water main of the city and the rail return.

"This is mentioned here as in case it is found in future to be a means of inducing further flow of current upon the mains to their detriment, the Railway Co. must not be relieved of responsibility in the matter. * * * *

"The 6 in. pipe taken from the river will furnish an apt illustration of the damage resulting at the joints of mains from railway currents flowing through them.

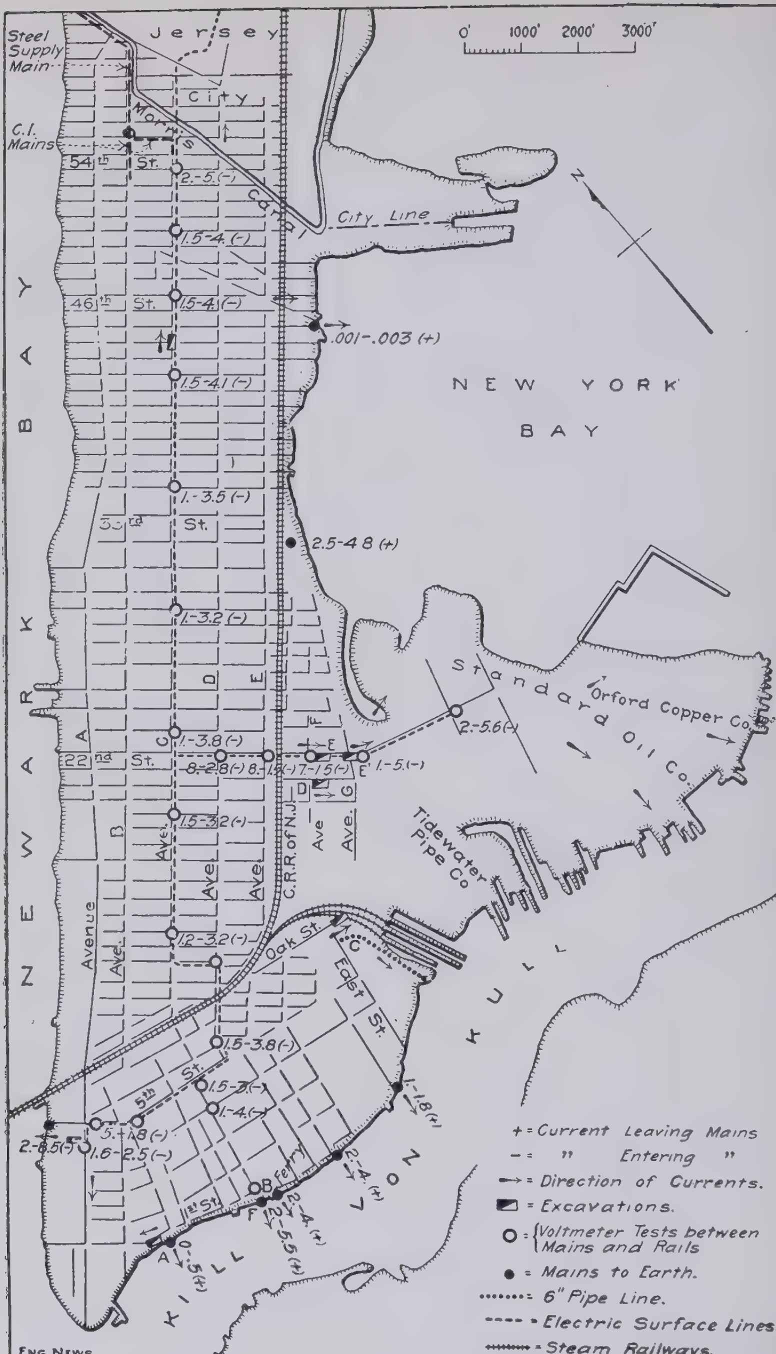
"This evidence which happens to be discovered at this time may be regarded as proving the wisdom of your Board in recently refusing, under our advice, to allow the Railway Co. to 'bond' the steel main to their tracks, the result of which would have been to divert a stronger current through this and other important mains connecting with same, such as the long 36 in. main and thereby increasing the liability of damage at the joints through electrolytic action in both systems, the steel and the cast iron."

BAYONNE, N. J.

The following description of an electrolytic investigation made in Bayonne is condensed from the "Engineering News" of Nov. 17, 1904. The cuts and table are not reproduced here:

A break in an important branch water main at Bayonne, N. J., about three months ago, led the authorities of that city to have an Electrolysis survey made by Mr. A. A. Knudson. The results are summarized in a report to the Mayor and Common Council of the city, and reveal serious conditions as to stray electric railway currents, and electrolytic corrosion of underground metals in Bayonne.

The Bayonne case presents a clear and simple aspect, because the electrolytic effects are of the same character throughout the entire outer edge of the city. The case differs therein



Map of Bayonne, N. J., Showing Results of an Electrolysis Survey Made by Mr. A. A. Knudson, September, 1904.

from the ordinary case, where there is a fairly well defined "positive district" in which most of the damage occurs:

Voltmeter readings were taken over all of the lines. All of the tests between mains and rails show mains negative to rails, the current leaving the tracks and taking the mains in all streets of the city where they parallel. There is no "positive area" in the city, in the sense of mains positive to rails. This is due to the fact that the powerhouse is located in Jersey City, some five miles from the central part of Bayonne.

The readings on Avenue C between mains and rails are such as may be expected upon a fairly well-bonded road, and the same may be said of the tracks upon 22nd Street. The 5th Street line, however, presents a case of rank negligence, so far as the track return is concerned. The voltmeter readings and other observations show the tracks unbonded at the joints, and not carrying current except perhaps when the car is a few feet away. Differences of potential up to 12, 18, and 25 volts have been found. Residents along the route report frequent illuminations at the track joints. Since the rails afford practically no return, current makes its way back to the power-house by the water-mains to the shore, thence, through the waters of New York Bay and Newark Bay to the power-house in Jersey City, which is located on the marsh near the shore. (See map on opposite page.)

The measurements show that there are two paths by which current enters the mains and passes back to the power-house. One of these paths is in a northerly direction by way of mains passing into Jersey City; some of the current goes by way of the 20 in. main which crosses the canal bridge at Avenue D and connects with the mains in Jersey City, and some goes by way of the large supply main which passes into Jersey City further to the West. The second path has been found to be by way of the shore ends of practically all mains that extend to tidewater, the current going thence through the water to the power-house. As the city is surrounded by salt water and marshes, in which several mains are imbedded, the conditions along this second path are very favorable to electrolytic destruction.

CONDITIONS WHERE BREAKS OCCURRED.

Main in East 22nd Street.—The corrosion and break of the 12 in. main in East 22nd Street is most important, as upon this main several important industries at Constable Hook depend for water. This main burst during the night of August 6, 1904, causing much loss in time and money to works depending on same for water; owing to the break being under tidewater, great trouble and expense was incurred in making repairs. Besides this, it is stated that some 4,000,000 gallons of water went to waste before the leak could be located and water shut off.

This leak took place in the made street, crossing the salt meadows, about 300 ft. east of Avenue F, and near a culvert through which a tidal creek passes under the street. It was evident from a few tests that railway current was passing out of the main into the soil at this point, thus causing the damage.

The current flow was determined by the "fall of potential" method at two places upon this main, one at either side of the marsh where the break occured (E and E_1 on map), to determine how much of this current was straying into the marsh.

These determinations show that the current upon the main is flowing east, with a decrease of current in the marsh, which decrease is accountable for the break. This decrease, representing current leaving the main at this point, undoubtedly is at present causing further damage to this main. For instance, referring to the readings taken at the comparison test :

AVENUE F.

Maximum 51.1 amp.
Minimum 21.9 " } =Average 36.5 amp.

AVENUE G.

Maximum 25.5 amp.
Minimum 14.6 " } =Average 20.0 amp.

Average loss.................... 16.5 amp.

This average loss of 16.5 amperes, or 45 per cent. of the average current at Avenue F, is escaping from the main into the marsh during the heavy traffic lasting about two hours each morning and evening. During the remaining 20 hours the current varies according to the traffic on the cars.

Permanent connections have been made upon the main at Avenue F with insulated wires, and the ends brought to the surface of the street through a pipe covered with a screw cap, so that the future current flowing through this main may be conveniently measured.

Two confirmatory tests were made of the potential differences between the main and soil of the marsh. One, nearest where the break occurred, showed a reading with main positive to soil of 0.3 to 0.7 volt.

The other 55 per cent. of the current remaining on the 12-in. main is distributed through various other pipes and metals at the lower Hook, and thence to soil, causing damage wherever it leaves the metal for the soil. One of these places is an 8-in. main near the Orford Copper Works, Lower Hook, which burst on March 21, 1904. This pipe also showed clear evidence of having been destroyed by electrolytic action.

Main in First St.—Another Electrolysis break occurred on First Street and Rathbun Avenue, in March, 1903 (Point A on map). This is a 6-in. main, and was replaced. The main is reached by tide-water, and is positive to the soil. The flow of current through the main was west, with a variation from 5.2 to 12 amperes; as the current is flowing towards the west, further damage is looked for upon this main. (See APPENDIX II, following.)

Main at the Coal Docks.—This main enters the salt marsh near East Avenue and Oak Street (Point C on map) and until recently was under tide-water in the marsh. About 420 ft. of this pipe have been removed, and about the same length was abandoned in the marsh, making about 840 ft. destroyed. Each one of the 25 lengths taken out of the marsh shows the characteristic marks of Electrolysis.

The electrical measurements on the main now in use show clearly the cause of Electrolysis and the destruction of the pipe removed. Tests made near the meter box where the

main enters the marsh at East Avenue and Oak Street, show a flow of current going east, ranging from 2 to 4.6 amperes. Potential tests show that the main is positive to the marsh by upwards of one volt.

These conditions, therefore, are all favorable for bringing about just what has happened, viz: the destruction by Electrolysis of this entire line of cast iron pipe.

Lead Service Pipe.—Another most pronounced case of Electrolysis was discovered while this examination was in progress (Sept. 19, 1904) by the bursting of a lead service pipe supplying water to Annex to School No. 5, located on 21st Street and Avenue F (Point D on map).

A portion of this pipe remaining in the ground was in a very similar condition to the piece removed. The electrical conditions show that railway current is leaving this pipe for the marshy soil, and another failure of this pipe is predicted in a short time. (See APPENDIX I, following.)

Summary.—All of the damage to the city water mains caused by Electrolysis is due to the railway current passing from them to tide-water soil. No case has been found where it passes back to the rails; and in this sense there is no so-called "positive district" in the city.

The remedy for Electrolysis in Bayonne rests with the street railway corporation operating its cars there. There are other ways than the "ground return" to bring currents back to the power-house in Jersey City. So long as the "ground return" is in use, so long will the currents find their way to the mains and pass out of them in the manner which we have described.

There are copper return systems in use, insulated from the ground, from which no injury to underground mains by Electrolysis is caused.

The full extent of damage by Electrolysis to the water mains in Bayonne may not be known until those in the marshes and water front have been removed. Several pipes as in 22nd Street being under tide-water, it is impossible to examine them. It is safe to conclude, however, from the experience with the 6-in. pipe to the Coal Docks (Point C on map) and from what has already occurred on the 12-in. main

in 22nd Street, that the latter main is practically ruined for about 1500 ft. where it passes through the marshy soil. The loss of the 840 ft. of 6-in. main through Electrolysis has already been stated.

The destructive effects upon the joints of mains where these railway currents are flowing through them have not yet been mentioned. This feature of Electrolysis is very difficult to locate because it is hidden. The result, however, is to cause joints to leak, causing much expense to the city for repairs. This flow of current prevails at present through a large part of the entire piping system, and if it has not already appeared it will in time make itself known.

APPENDIX I TO BAYONNE REPORT, OCT. 14, 1904.

Since the completion of this report the following additional casualties to water pipes have occurred at Bayonne:

The lead service pipe at Annex to School No. 5 (Point D on map) mentioned in the report, with the prediction that "it would again fail in a short time," was again found leaking, and on Oct. 10th the entire length, about 120 ft., leading from the main to the school building, was removed, and a galvanized iron pipe put in its place. This iron pipe is subject to the same effect as Electrolysis, but it will probably take a little longer time to cause its destruction than the lead pipe. The lead pipe which was removed has the usual stamp of Electrolysis throughout its entire length.

Another service pipe destroyed by Electrolysis is being removed from First Street, at the old Staten Island Ferry (Point B on map). One portion of this 3-in. iron pipe was found full of holes, caused by the escaping current. It is also stated that the service pipe at the new ferry slip adjoining is eaten through in about eighteen months' time. Electrical tests, at both the old and the new ferry slips, show the current flowing from the pipes to the Kill, and fully explain the cause of the failure at both places.

APPENDIX II TO BAYONNE REPORT, OCT. 31, 1904.

A further break occurred on the 6-in. main in First Street on Oct. 31st. This failure (Point F on map) took place about

one block west of Avenue C. A soft spot in the main about 2 in. in diameter was blown out, and was in such position that the stream of water forced its way up through the soil and over into the Kill von Kull some 50 feet away, very similar to a stream directed from a fire hose. On this account there was no damage by water to nearby property. The shutting off of water to repair this break, however, caused a serious loss and inconvenience to residents and others on this street. The large manufacturing establishment of the Safety Insulated Wire Co. was compelled to close its works for an entire day, leaving several hundred men idle, owing to loss of water which this main supplied.

The electrical tests taken at this point show the main highly positive to the waters of the Kill, which agrees with the previous tests. The readings were highest at the foot of Avenue C at the Ferry, where they ranged from 2 to 5.5 volts; a little further west where the break occurred they ranged somewhat lower, and were 0.5 volt further west at Rathbun Avenue. East of Avenue C or the ferry the conditions are quite similar to those upon the west side. This main near the fracture was softened entirely through the iron, with pittings upon other parts of its surface. The data collected shows that this break is a clear case of Electrolysis, for which the railway currents are directly responsible, and, as before stated, further breaks may be expected while these currents are upon this main.

A sub-station is at present (1906) in course of construction in Bayonne which will supply the current for that section of the electric road. The electrolytic conditions will be entirely changed when this station is in operation.

Boston and Vicinity.

The following is from the "Engineering Record" of July 29, 1905:

"There is probably no city in which Electrolysis phenomena are being watched more carefully than in the district containing the mains of the Metropolitan Water and Sewerage Board of Massachusetts, and in the report of the chief

engineer, Mr. F. P. Stearns, for last year, some very interesting notes on the subject are given. * * * In the annual report for the year 1903 detailed descriptions were given of the injury done to 48-in. pipes in Cambridge, 24-in. pipes in Chelsea and 12-in. pipes in Lynn, and also of an experimental test of an insulating covering of asphalt and burlap which was being made by the Boston Elevated Railway Co. On April 6, 1904, this covering, which was applied in November, 1902, was removed from one length of 48-in. pipe for the purpose of examination. Before the covering was applied the pipe was carefully cleaned and the pits dug out and located. Upon removing the covering many new pits were found, and in some cases one large pit was found where there were two or three separate pits before the covering was put on. The number of pits in the pipe had increased from 80 in 1902 to 496 in 1904. The railway engineers suggested that possibly the pits were not all dug out before the pipe was covered, and therefore re-covered it for a further test. They have since made the following experimental tests, which indicate that the covering has little if any value under some circumstances:

"A short piece of 4-in. pipe, covered in the same manner as the large pipe, was buried in dry earth in a box, and a cast-iron plate was buried 1.25 ft. from the pipe. In one test tar was used in the covering, and in another asphaltum. The pipe and plate were connected in the regular trolley circuit of 500 volts. While the earth was dry, the resistance between the pipe and the plate with the tar covering was 700 megohms [1 megohm = 1,000,000 ohms], and with the asphaltum covering, 34 megohms. The earth was then saturated with salt water, and the resistance quickly diminished, and after seven to ten days disappeared.

"For the purpose of diminishing the injury which was being done to two lines of 36-in. pipe crossing under the Charles River near the power station of the Boston Elevated Railway Co. in Cambridge, two 48-in. insulating joints were set in July, 1904, one on either side of the river. Each of these joints was composed of two flanged pieces of 48-in. pipe, bolted together with a gasket of pure rubber ½ in. thick between the flanges. The bolts joining the flanges

were covered with rubber tubing ⅛ in. thick, and the nuts were insulated from the casting by means of a washer of rubber ½ in. thick. The joints have resistance of from 100 to 200 ohms when the pipe is filled with water, and are enclosed in waterproof chambers, to prevent the entrance of ground water.

"These joints reduce the quantity of electricity leaving the 36-in. pipes in the river from 25 to less than 5 amperes, and reduce the quantity flowing along the pipes toward the power station from 65 to 40 amperes. The joints were expected to protect the pipes in the river at the expense, to some extent, of other portions of the pipe line; and the measurements of currents appear to show that the effect has been substantially as expected, as the quantity of electricity leaving the pipe between Western Avenue, Brighton, and the river was increased about 25 amperes. As these joints reduced the quantity of electricity flowing along the pipe line, the railway company desired to set similar joints at other points, and late in the year an arrangement was made for the setting of four additional 48-in. joints. As the amount of current flowing along the pipes at different times depends upon the amount of power developed at these times at the different power stations, many observations are necessary to determine the average quantity flowing even for a single day, and these have not been taken since the last joints were installed; but enough measurements have been taken to warrant the statement that the introduction of the joint at one of the places has substantially stopped the flow of electricity along the pipe at that point. The conditions have been changed so as to increase the amount of electricity leaving the pipe north of the joint, but there appears to be at present not more than 40 amperes flowing along and leaving the pipe line, in place of 90 amperes; and there has also been a very marked reduction in the difference of potential between the pipes and the rails of the street railway company.

"The measurements thus far taken appear to indicate that the effects of setting an insulating joint somewhere near the middle of a pipe line, one portion of which is electrically positive and another negative to the car tracks, are as follows:

1. To stop the direct flow of electricity along the pipe line at the point where the joint is set, and to reduce considerably the amount of electricity flowing along other parts of the pipe line.

2. To lower the average potential of the pipe line on the negative or power-station side of the joint.

3. To raise the average potential of the pipe line on the positive side of the joint.

4. To maintain a difference of potential of several volts between the positive and negative sides of the joint, and to produce conditions tending to increase electrolytic action at that point, unless the joint is carefully located in dry ground.

5. To cause a new distribution of electrical conditions, under which the two sections of the pipe line become similar to the original line, with one portion of each positive and the other negative to the car tracks, so that the number of positive areas is increased by one for each joint.

"Both in August and November, 1903, the attention of the officials of the Boston & Northern Street Railway Company was called to the serious injury which had been done to the Board's pipes, both in Chelsea and Lynn, by the currents of electricity returning to its power stations. Excavations made in November in Lynn showed that there were pittings in a 12-in. pipe 0.45 in. in depth, leaving only 0.25 in. of the original thickness of iron. As it was not deemed prudent to continue to risk the failure of this pipe line, it was relaid during the past year for a length of 593 ft. All of this pipe was laid in 1898, and when removed it was badly decomposed, and in several places very little of the original metal of the pipe remained. The officials of the railway company were notified that the pipes were to be relaid before the work was commenced, and were asked if they desired to adopt any preventive measures, but they did not do so; and on December 5, after the pipe was relaid, measurements showed that there were 20 amperes of electric current leaving the relaid section. It is probable that, if nothing is done to alter the conditions, it will be necessary to again relay these pipes not later than 1910.

"The regular annual survey to determine the relative

electrical potential of the Metropolitan pipe lines and the street railway tracks, and the amount of electricity flowing on the pipes at the several gauging stations, was made in April. In making these surveys, voltmeter readings were made at each station every twelve seconds, for a period of five minutes. The figures are obtained from readings taken between 9 A. M. and 4 P. M. during the months of March and April, and do not represent the extreme results which would be obtained during the hours of maximum travel. The average of these readings, compared with similar readings made in 1903, shows that the electrical pressures have been generally reduced during the past year over the entire distribution system.

"At a few points, however, the conditions are worse than in 1903. At one place in Brookline the voltage between the pipe and the rails has increased from 2½ to 5 volts, possibly due to increased traffic on the Boston & Worcester line. At a place in Milton the average voltage has increased from 18 volts in 1903 to 22 volts in 1904, and the maximum from 35 to 60 volts. This is due to poor track construction, and lack of return feeders on the Old Colony Street Railway Co. Early in the year the Boston & Northern Street Railway Co. was notified that there was a large difference of potential between the Board's pipes and their tracks in Stoneham, and that a large quantity of electricity was flowing along the pipe. During the past year the railway company has relaid the tracks and provided better returns for the current, so that the conditions have been greatly improved; but even now there is considerable current flowing along the pipe.

"In January the attention of the Old Colony Street Railway Co. was called to the fact that a current of from 15 to 45 amperes had been measured flowing on a 12-in. pipe in Hyde Park, with differences of from 5 to 18 volts between the pipe and the rails. In June the pipe was uncovered at several points for examination, and pits about $\frac{1}{16}$ in. in depth were found on several pipes. A service pipe of the Hyde Park Water Co. was found to be resting upon the 12-in. pipe, making an electric contact by means of which about 10 amperes of electricity passed from the Metropolitan main to the pipes of the Hyde Park Water Co. By raising the service pipe and

breaking the electric connection, the flow of electricity along the pipes was reduced about one-half."

Chicago, Ill.

In order to ascertain the exact electrical condition of the gas piping controlled by the Peoples Gas Light and Coke Company, a complete electrical survey of the City of Chicago was made in the spring of 1901, and the following information has been supplied:

The surveys were undertaken to determine how much of the piping and what portion of it was positive to the rails and to the earth; that is, the portion in which the current was leaving the pipes for the earth and where Electrolysis was taking place. Wagons were equipped with voltmeters and ammeters and a crew consisting of a driver and four men, and readings of potential differences were taken on every block in the City of Chicago. These were obtained by connecting one voltmeter terminal to the rail, and the other to some portions of the main, or to a pipe connected to the main, as to a lamp post, a drip pipe, or a service pipe in the basement of a neighboring house. To determine the current strength, measurements were made of the potential differences between points on the main of known distance apart, and, knowing the resistance of a given length of the pipe, the amperes of current were calculated by Ohm's law. The direction of the current was also noted.

When the results were plotted, the city was divided into three kinds of districts: First, negative districts or the parts remote from the power houses, where the current is leaving the rails and flowing through the earth and entering the pipes. Second, positive districts in more or less immediate proximity to the power houses, where the current is leaving the pipes, and where most of the Electrolysis is taking place. Third, the regions between the negative and positive districts, where the current sometimes enters and sometimes leaves the pipes. The extent of these intermediate districts varies according to the load.

The positive voltage was found to range from to 1/10 to 30

volts, although for the most part the average was from 2 to 6 volts. The current being carried by the pipes varied from 0 to 150 amperes and averaged about 20 to 60 amperes.

The city was then charted from a map and the positive areas were found to be as follows:

North Side,	280,000 ft.
West Side,	541,100 ft.
South Side,	635,425 ft.

making a total of 1,456,525 lineal ft., or 276 lineal miles, which is about 13 per cent. of the total mileage of mains in Chicago.

Since the Gas Companies could not prevent the flow of electricity to their pipes, upon the pipes and off of them again, their efforts were directed toward the prevention of the flow of current from the pipes *into the moist earth.* To this end, all of the pipe joints in the *affected* districts in Chicago have been bonded, and the current taken off through metallic conductors, at various intervals, instead of being allowed to go into the earth.

While the bonding of the pipes to each other around the joints, and connecting them to the negative side of the dynamos in the respective power-houses of the street railway companies would entail disadvantages and danger in the shape of vastly increased current flow on the pipes, nevertheless this method appeared to offer means of substantially remedying the existing conditions, and of saving the piping in the affected districts from total and early destruction.

To do this, it was necessary to bond and connect the different pipes so that they formed the *best* return circuit for the stray currents that reach the pipes, and in this way a flow of current to the pipes which is harmless was induced, and not away from the same which is known to produce Electrolysis. To this end, electrical measurements were made, and knowing the size and resistance of the rail and of the pipe, and of the joints [?] in each, the size and amount of copper to bring about these results was determined upon. As a general thing copper wire of about ½ in. diameter (#0000) was used for the bond around each joint in the pipe. To install these, each joint of pipe in the positive district was uncovered and

a hole was drilled on each side of joint, and a plug was driven into the hole and soldered; then a bond wire of the above size was soldered in, to connect the plugs. Voltmeter readings were taken during the entire progress of the work, and at intervals heavy connecting wires were run from the pipe system to one or more return wires installed on the poles carrying the feeder wires at the side of the street. These connecting wires were installed about every 600 feet, the space varying, of course, with the size of the main and with the volume of current to be returned, the intention being to connect at the points where the potential was highest.

It was found that the best results could not be obtained by simply connecting the pipe system to the rails or to the underground return feeders of the railways, hence independent return feeders were placed upon the pole lines. These varied in size from ½ in. in diameter (#0000) to 1¼ in. (1,000,000 cir. mils). These return feeders were led into the power-houses and connected to the negative bus bars.

By these means the positive area has been reduced to less than 2 per cent. of the mains which were undergoing deterioration at the time the work was taken up. There are a few small positive areas left due to local causes, in which the voltage is so low that it was not deemed necessary to go to the expense of bonding, and doubtless there exist and will continue to arise small affected areas, due to broken rail bonds, etc., but the bulk of the trouble appears to have been overcome.

Considerable difficulty was experienced in bonding the pipes on account of the varying conditions. The bonding on one street would cause conditions on another street to change, and difference in the amount of traffic also caused very perplexing variations. The bonding of the gas pipes altered the conditions in regard to the water pipes, and to the telephone cables, and in some instances it was necessary to bond the lead sheaths of the telephone cables to the return system of the gas pipes.

While bare conductors would have been entirely adequate for the return circuit, bare overhead wiring is not permitted in Chicago, hence the return cables were all insulated.

For the maintenance of this system, it is essential that the

street railway companies retain good bonding on their rails; and that the joints in the gas pipes be kept tight and electrically conductive.

DETROIT, MICH.

The result of an electrolytic survey of the water and gas pipes of Detroit, made by Mr. A. A. Knudson in 1905, are given in a report addressed jointly to the Board of Water Commissioners and the Detroit City Gas Co. The following abstract of this report is given with the permission of the above parties:

THE DETROIT SITUATION.

The present situation, as a result of previous attempts to avoid damage by electrolytic action, is briefly as follows:

In 1896, the first examination authorized by the Board of Water Works appears to have been made under the supervision of the then general superintendent, Mr. L. N. Case.

At that time there were three electric railway companies operating in the city, the Citizens' Railway Company, the Detroit Railway Company and the Fort Wayne and Belle Isle Railway Company. The latter was not considered a source of danger, its system being comparatively small.

The plan for protection which was pursued is outlined in the following extract from Mr. Case's report: "The necessity, first, is to keep the electricity off from the pipes as much as possible in those districts where there is a tendency to overflow from the rails. This can be accomplished by providing a more liberal system of return conductors. The uninterrupted conductivity of the rails should be first insured, an additional feeder of copper wire being sometimes used independent of the rails.

"The next step is to arrange special return wires from the pipes to the rails or to the return cables in what are known as the danger districts, which are almost entirely within a short radius of the power houses."

The quotations are made for the purpose of establishing the

origin of the bonding system found generally in vogue in Detroit upon the *water* mains.

The bonding of *gas* mains to the railway returns was probably begun in June, 1903. It was found necessary to place bonds around the lead joints of the 12-in. w. i. main in Riopelle Street to prevent their melting out, owing to the heavy currents flowing through them, which were caused by its connection with the railway returns. A few other bonds have been placed upon gas mains at other points in the city.

We will now consider the situation as found at the present time. Since the first bonds were placed upon the water mains, the railway companies have combined and are now operating under one management, called the Detroit United Railway Company. This company has freely co-operated with the Water Department in efforts to avoid Electrolysis. They have installed bonds and connections to pipes with their returns at their own expense, first obtaining the consent of the parties owning the same, and are keeping watch through annual voltmeter surveys of danger districts in all parts of the city.

GENERAL REVIEW OF SURVEY.

Over 150 measurements were made upon the water mains, and nearly as many upon the gas mains.

The danger points in Atwater street refer to gas entirely. One service pipe was found leaking where it was exposed by the excavation for the new 10 in. water main, which leak was due to Electrolysis.

This (+) condition of gas pipes is without doubt, caused by both the fire main and the water main in the street being bonded to the railway return. The recent bonding of the fire mains has brought about this result in several places in the city, one marked instance being at Cass Avenue and Lafayette Street, where both water and gas mains are positive to those mains, and another at Miami Avenue and Witherall Street; at the latter place the two water mains and the fire main have been bonded together. The 4 in. gas main found at this opening was considerably damaged by Electrolysis.

Jefferson Avenue.

Several gas service pipes have been destroyed through this part of the street, and about 30 feet of 4 in. c. i. main replaced with new pipe, all owing to Electrolysis. Between October 17th and 31st, the 4 in. c. i. gas main was bonded to the 12 in. w. i. gas main by the railway company with a view to stopping further damage.

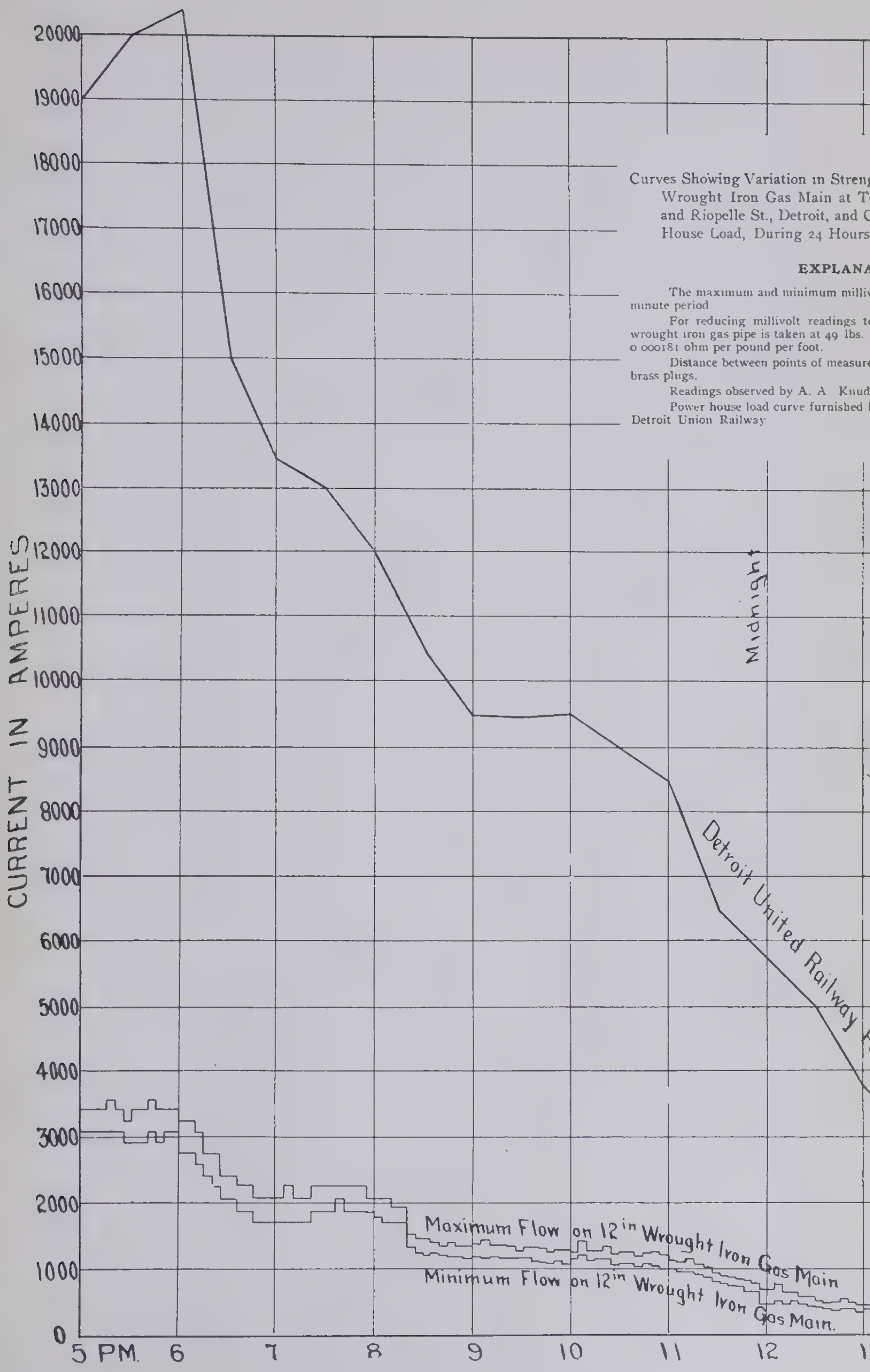
It should be understood that as the 12-in. w. i. gas main is connected to several railway negatives, both underground and overhead, which lead direct to the power-house, bonding the 4-in. gas main to it, practically connects the entire system of gas mains in this vicinity to the railway returns. The same may be said of another case of bonding at Fort and Riopelle Streets, where the 4-in. gas main was bonded to the 8-in. water main, the water main being already connected to an overhead negative.

At Fisher Avenue we find a maximum flow of 341 amperes. This is further added to as shown at Field Avenue, making 373 amperes, the flow being west at both tests. At Bellevue Avenue (same time of day as at Field Avenue) it is 148 amperes.

At Meldrum Avenue the 42-in. main turns north and thence goes through Congress Street. As the pipes and rails on Jefferson Avenue are bonded at nearly every street running north and south, a flow south is found, where tests have been made, to the pipes in Jefferson Avenue as far as Riopelle Street. At this point all pipes, both water and gas, are bonded not only to rails, but to special cables, both underground and overhead, running to the power-house at the foot of this street.

There are two large gas mains in Riopelle Street crossing Jefferson Avenue, one a 12-in. w. i. main previously spoken of, and the other a 16-in. c. i. main; both are carrying railway current, but the 12-in. main, owing to the screw coupling joints making the best conductor, as against the lead joints in the c. i. main, carries much the greater current.

The drawing [not reproduced here] shows the method of bonding around the several c. i. parts in the 12-in. main



Curves Showing Variation in Streng
Wrought Iron Gas Main at T
and Riopelle St., Detroit, and C
House Load, During 24 Hours

EXPLANA

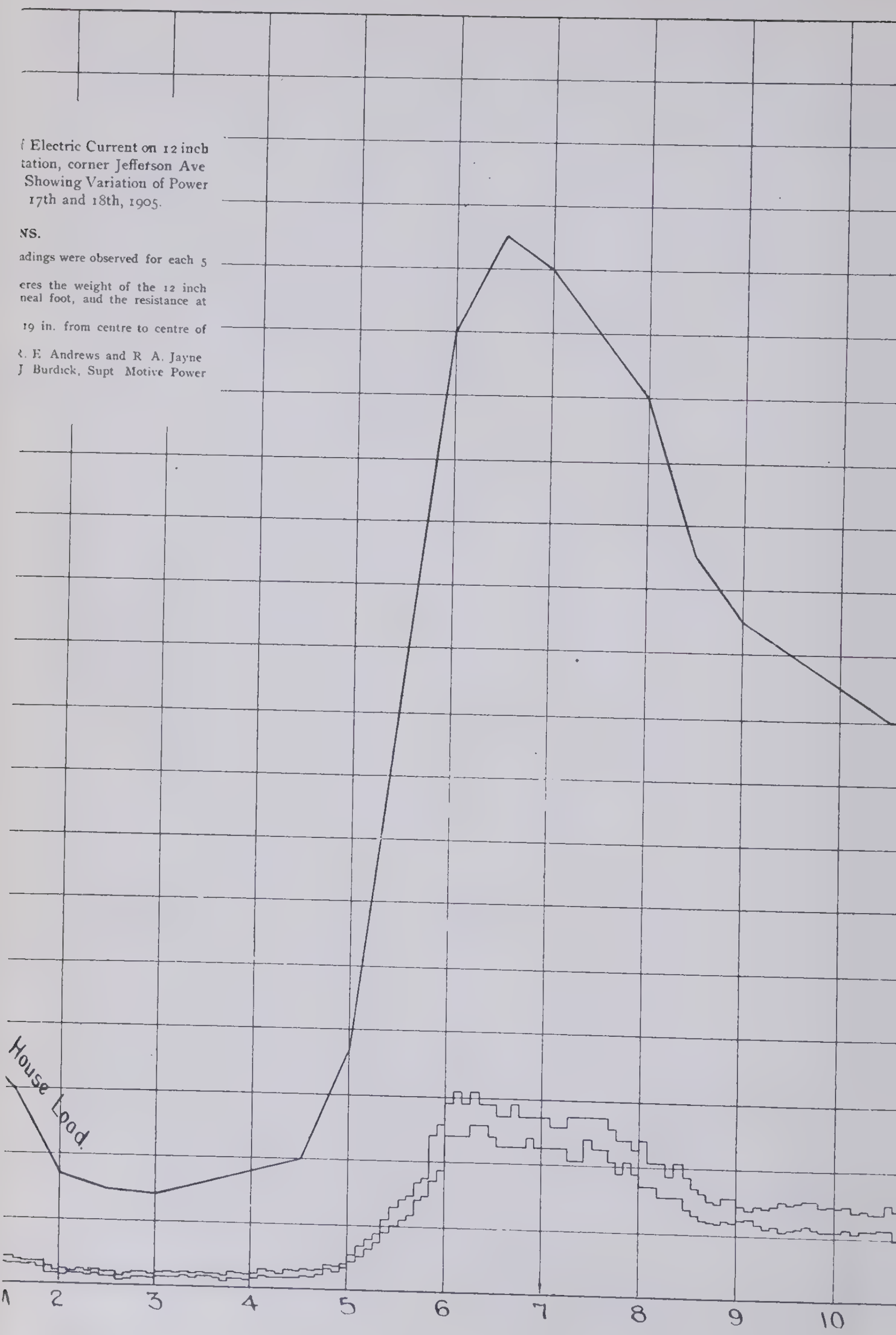
The maximum and minimum milli
minute period

For reducing millivolt readings t
wrought iron gas pipe is taken at 49 lbs.
0 000181 ohm per pound per foot.

Distance between points of measure
brass plugs.

Readings observed by A. A Knud

Power house load curve furnished
Detroit Union Railway



ᶠ Electric Current on 12 inch
tation, corner Jefferson Ave
Showing Variation of Power
17th and 18th, 1905.
NS.
adings were observed for each 5
eres the weight of the 12 inch
neal foot, and the resistance at
19 in. from centre to centre of
R. E. Andrews and R. A. Jayne
J. Burdick, Supt. Motive Power
House Load.
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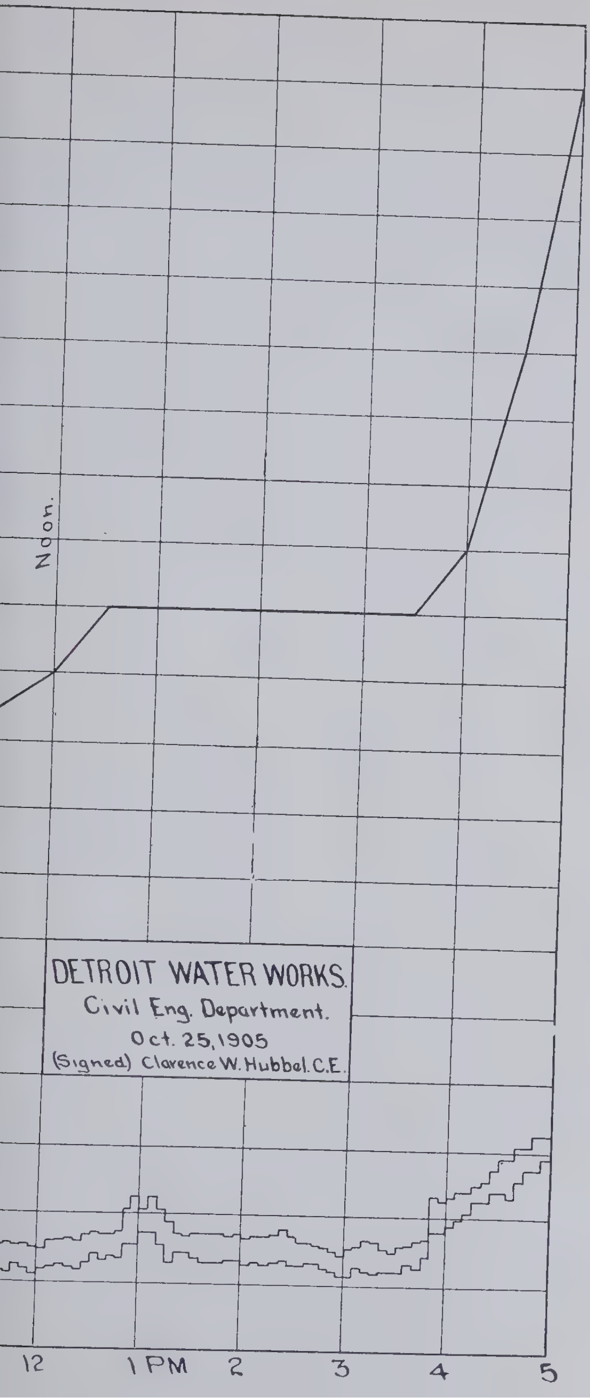
Noon.
DETROIT WATER WORKS.
Civil Eng. Department.
Oct. 25, 1905
(Signed) Clarence W. Hubbel. C.E.
12
1 PM
2
3
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5

containing lead joints. This copper cable was placed in this way so as to prevent the lead joints from melting, as had been the case in one or two instances due to the heavy current passing through the main since it was connected to the railway negatives.

The other two one-million cir. mils cables connect with other larger cables which lead to the power-house.

The Twenty-Four Hour Test.

In view of the heavy flow of variable current at times upon this main and the desirability of establishing the readings at any time in 24 hours for future comparison, a series of highest and lowest millivolt [1 millivolt = 0.001 volt] readings was taken every five minutes, beginning at 5 P. M. on October 17th, and ending at 5 P. M. on October 18th.

The current flow in amperes has been deduced, and the whole plotted upon the accompanying curve sheet. On this sheet the power house log is also plotted for the same hours. It will be noted that the variation of current strength of the power house load is faithfully reflected by the variation of current strength on this main, making the identification of the source of current on the main complete.

Increase of Railway Current.

As a traction system expands and more cars are added, more current is required to move the same, consequently an increased amount of current will return by the mains.

Another reason for the increase of current strength upon underground mains is the bonding of mains to rails or to negative bus-bar, also bonding one set of mains to another, such as gas mains to water mains. An idea of such an increase is given in the following comparative tables, in which an average is obtained of three readings selected from the evening load at the power house, and three readings from an evening load on the gas main, showing the per cent. of increase in the past two years.

Switchboard Readings, D. U. Railway Power-House, During Evening Rush Hour Years 1903 and 1905					Current Flow on 12 in. W. I. Gas Main Years 1903 and 1905				
Time	Date	Amperes	Average	Inc.	Time	Date	Amperes	Average	Inc.
P. M.	1903 May				P. M.	1903 May			
5.00	28	11,000			5.00	28	2,290		
5.30	"	13,500	13,000		5.45	"	3,050	2,848	
6.00	"	14,700			6.00	"	3,205		
	1905 Oct.					1905 Oct.			
5.00	17	19,000			5.00	17	3,400		
5.30	"	20,000	20,000	53%	5.45	"	3,600	3,410	20%
6.00	"	21,000			6.00	"	3,250		

Fire Department Mains.

This system of mains is used solely for fire protection, and they are generally known and spoken of as "Fire Boat Mains," as during fires water from the Detroit River is pumped through them by a fire-boat.

These mains, which are so important to the city, have been seriously affected by Electrolysis. We have already referred to one of the effects of current flow through them—the possibility of damage at joints.

These mains, as well as the gas and water mains, are connected with the negative return to the power-house, the connections, with few exceptions, having been made during the past summer.

Current Action at Joints.

During this survey the question arose, in the event of further bonding being allowed from gas and water mains to fire mains, how much added flow could be delivered to the fire mains without danger of melting some of their lead joints. [The details of the tests made to determine this are omitted, but the conclusions are given on page 823.]

CONCLUSIONS AND SUGGESTIONS.

Bonding.

"The bonding of water mains to railway return conductors, as a protection from Electrolysis, was commenced in Detroit in 1896, and has continued to a more or less extent since then.

"The traction system was small at that time as compared with the present. It was supposed then, no doubt, that the same method would answer for large, as well as for small systems.

"Where the safety of all underground pipes is considered in the streets of a city, we are of the opinion that it is not wise to depend upon the bonding method as a final cure for Electrolysis, especially where a large traction system using a ground return is in operation.

"Where such a system has been in vogue for several years, however, as in Detroit, it is not advisable to make any sudden or radical change without first having a substitute in use known to be equally efficient.

"Referring to other methods of protection, we quote the following extract from A. V. Abbott's work, entitled, 'Electrical Transmission of Energy,' 1904, page 102 (an authority on the subject), which we believe will apply to the situation in Detroit. After referring to damage by Electrolysis to underground pipes, lead cables, etc., he says: 'On account of these difficulties the larger roads are now aiding the ground return by re-enforcing it with copper wire return feeders, looking in the near future to a more or less complete metallic circuit for the railway system.'

"While the *complete metallic circuit*, such as in practical use in New York, Washington and Cincinnati (conduit system and double overhead trolley), has not come into general use, the tendency, at least among large railway systems, as Abbott indicates, is in that direction, and something of this kind should be adopted in Detroit.

"If the *complete metallic circuit* is installed there will, of course, be no further danger from Electrolysis of underground

mains. In the meantime the situation in Detroit will have to be considered and dealt with as found.

"The system of bonding, while it has advantages, has also disadvantages; for instance, where one set of mains, such as water mains, are bonded to the railway return conductors, other mains in the same streets are, on this account, made electro-positive to them; and, unless also bonded, will be injured by Electrolysis. This is the experience covering several years in Detroit.

"Another result from bonding: A much greater flow of current is invited upon the mains, and Electrolysis action at joints is apt to occur, especially when the currents are heavy. On account of these and other objections, we have never favored the method of bonding mains to rails, or to negative returns, preferring means to keep currents off mains, rather than recommending means which make them a part of the return circuit to their detriment.

"In Detroit, however, we find at the present time the water mains and fire mains bonded and the gas mains also bonded to some extent. To prevent immediate electrolytic action upon the gas mains that are now in danger, it will be necessary to bond them also, at least as a temporary measure, until the railway company so improves its return system as to relieve the flow of current upon all underground mains in the city.

"Mr. Burdick, Superintendent of Motive Power of the D. U. Ry., has informed us that he stands ready to do this, and, therefore, we have reason to expect a substantial improvement in the near future in the reduction of the heavy currents now passing through some of the mains, as well as from one system of pipes to those of another system.

Joint Melting Test.

"This has been explained in detail, and is important in determining what was hitherto unknown, viz: how much current a lead joint will stand before melting. It was found that a poorly made joint, with much less lead than the average, in an 8-in. water main, in service 38 years, tested in the open air, no water inside, required a current of 2,600 amperes for

14 minutes to cause the lead to melt. More perfect joints will stand more current without failure under the same conditions of test. In view, however, of weak or imperfect joints, such as may be in smaller water mains or in a gas main that is near the surface of the street, subject to changes of temperature, and the consequent expansion and contraction, causing high resistance, it is not safe to permit any such flow of current through mains of any size containing lead joints.

"Taking all sizes and kinds of underground pipes, length of service, etc., into consideration, it is our judgment that a *maximum flow of* 900 *amperes is the highest that should be permitted upon any underground main, so far as danger of melting the lead joints is concerned.*

Electrolytic Action at Joints.

"Many joints have been examined, both gas and water, in the cast iron mains, interior as well as exterior. The result has been that, while in some cases evidence of electrolytic action has been found, as a whole no serious damage can be reported. The size of joints examined were from 4 in. up to 12 in. As a rule sizes above 12 in. are not as much affected as the smaller ones, owing to greater surface contact of the metals and consequent lower resistance. It is to be observed, however, that the heavier the flow of current through the mains, the more chance there is for electrolytic action at the joints that are more or less imperfect. The flow of nearly 400 amperes on the 42 in. water main in Jefferson Avenue is for this and other reasons deemed liable to be injurious at some joints in this main.

"The rails are well bonded, but the principal cause for diversion of current to this main is that the mass of cast iron in the main offers a conducting path which competes successfully with the rails in carrying capacity.

"Another instance is a joint in a 24-in. main which shows high resistance even after being newly calked (owing to a leak) at Congress and Randolph Streets. The flow at one test through this main was 203 amperes.

"This joint is still in service and exterior examination

shows electrolytic action on the (+) spigot side close to the lead packing. As a rule, however, we have found very few joints showing high resistance. A reason given by Mr. Hubbell is that much care is given to the packing of all lead joints. This statement is borne out by personal observation.

The Twenty-Four Hour Test.

"The curve sheet shows the minimum and maximum strength of current during the twenty-four hours returning through the 12-in. w. i. gas main. This main is connected by heavy copper cables to the power-house which accounts for the heavy flow, at times above 3,000 amperes. The power-house load current is also plotted on the same sheet and shows the similarity in variations at the same hours. The railway company has agreed to substantially reduce this flow upon this main by constructing additional track auxiliaries.

"Attention has been called to the increase of current strength of the traction system during the last two years. A short table shows 53 per cent. increase in two years time at the D. U. Railway Station, and 20 per cent. at the gas main above referred to, between the years 1903 and 1905.

"As it is probable that the same ratio of increase may be expected in future, unless a change is made, it is our opinion that a condition is being approached which makes it imperative that the railway company should make such change as soon as possible, at least before another summer's traffic commences."

* * * * *

New York City.

ELECTRIC RAILWAY SYSTEMS.

The electric railways in New York City may be divided into three divisions: The Elevated System, the Subway System and the Surface System. 600 volt direct current is used for operating each system. The electric power is chiefly generated in main power houses located on the water front, in the form of three-phase 25 cycle alternating currents at either 6,600 or 11,000 volts pressure. This is converted into 600 volt

direct current in a number of sub-stations which are located at approximately equal intervals along the railway line supplied. Each sub-station supplies this direct current to that section of the line which is within its own economic area. For the purpose of discussing the question of Electrolysis each sub-station may be considered as an independent power station. The arrangement of conductors to convey the direct current from the sub-stations to the moving trains is briefly described for each system in the following:

The Manhattan Elevated Railway.—The motive power of the Manhattan Elevated Railway was changed from steam to electricity during the years 1902 and 1903. The electric power is supplied from seven sub-stations having an aggregate normal capacity of 61,500 kilowatts, which, at the 625 volts pressure generated, is equal to 98,400 amperes.

The positive supply feeder consists of a contact rail, or third rail, installed on vitrified clay insulators. This contact rail weighs 100 pounds per yard and is made in sixty foot lengths of a special grade of low carbon steel giving about ⅛ the conductivity of copper. The rail joints are bonded with four solid bonds of drop-forged copper having a total conductivity slightly greater than the rail. The feeder system is divided into sections, each section covering the distance between two sub-stations. The contact rails for up and down-town tracks are connected with cross bonds and usually no additional copper feeder cables are required. Current is supplied at each sub-station from the positive bus-bars through a 10,000 ampere circuit breaker and switch. The division between sections occurs opposite each sub-station, and a sufficient gap is left in the contact rail so that a single motor car cannot span across from one section to the next. This arrangement of the positive feeder system utilizes to the fullest extent the conductivity of the contact rails and enables the load to be equalized between sub-stations.

For the negative or return side of the direct current feeder system, the elevated structure and track rails are bonded together, thus forming a return path of great conductivity, so that the drop in the return circuit is very small. The track rails are ninety-pound high carbon rails bonded together with

one #0000 copper cable per joint. At intervals of ninety feet, the track rail is bonded to the top chord of the longitudinal girder by means of a #000 flexible copper bond. The upper and lower chords of the longitudinal girders of the structure are bonded together with from one to four #0000 copper bonds, the number of bonds increasing toward the sub-stations.

The structure and track return are connected, by means of bare 1,500,000 cir. mils cables, to the negative bus-bars in the sub-stations.

The Subway System.—The subway system in New York City was opened for traffic during 1904 and 1905. The electric power is supplied from eight sub-stations which are located at an average distance of 12,000 feet apart and which have an aggregate power output of about 50,000 kilowatts, or about 80,000 amperes at 650 volts.

The positive feeder consists of a contact rail supported on insulating blocks of reconstructed granite. The contact rail weighs 75 pounds per yard and is made in sixty foot lengths of a low carbon steel giving about 1/8 the conductivity of copper. Each rail joint is bonded with four 300,000 cir. mils copper bonds. The contact rail is divided into two sections between sub-stations, one section being supplied with current from each sub-station. At a point half way between sub-stations, the two sections are normally closed through quick-break switches. The contact rail is supplied with current through feeder cables which are connected to the rails at points along the lines. The feeder cables are all 2,000,000 cir. mils stranded copper cable, insulated with paper and covered by a lead sheath.

For the return circuit, one rail of each track is used, supplemented by copper return cables. The other rail is used for signaling purposes. The negative cables are identical in size and insulation with the positive cables. The track rail is a high carbon rail weighing 100 pounds per yard of American Society standard section in thirty-three-foot lengths. The joints in one rail of each track, used for the return current, are bonded with two 400,000 cir. mils copper bonds, placed under the splice bars.

The negative bus-bars and return feeder cables are insulated from the ground. The tracks are also laid on a heavy stone ballast, which secures high resistance to ground.

The Surface System.—The Metropolitan Street Railway Co.'s system includes all the street surface railway lines of the Boroughs of Manhattan and the Bronx. Its lines in the Bronx also extend widely into the adjoining county of Westchester, its northerly termini in the villages of Tarrytown, White Plains and Mamaroneck being distant about thirty-three miles from the southern extremity of the system at the Battery. Within these limits, with about 500 miles of single track, it serves a resident population of nearly two and one-half millions, of which all but about four hundred thousand are south of the Harlem River.

The surface railways in the Borough of Manhattan have insulated positive and negative conductors placed in conduits to convey the current to and from the moving cars. This is known as the double conductor conduit system, and, as the return circuit is completely insulated, there are no stray currents to endanger the pipes buried in the ground. There are at present over 200 miles of this conduit road in operation on Manhattan Island, all of which has been installed since 1896.

The surface railways in the Borough of the Bronx and in the adjoining territory are operated by means of the single overhead trolley for the positive, and the rails, augmented by insulated return cables, for the negative or return circuit.

The Brooklyn System.—The Brooklyn Rapid Transit Co. operates all but one of the surface railways and the entire elevated railways in the Borough of Brooklyn.

These comprise a total of 544 miles of single track, of which 478 miles are surface and 66 miles are elevated tracks.

The electric power for operating the cars of the Brooklyn Rapid Transit Co. is generated in six steam power stations; at five of these stations direct current only is generated, and at the other both alternating and direct current. Alternating current from the latter is supplied to seven sub-stations which distribute direct current to the feeder system. There are, therefore, stations in all which are centres of distribution of the direct current.

On the elevated railway a third rail is used for the positive feeder, and the service rails and the iron structure are bonded together and are used for the negative or return feeder. The arrangement is similar to that used on the Manhattan Elevated Railway.

The surface railways are operated with a single overhead trolley for the positive feeder. For the negative or return circuit the rails are used, together with a number of negative return feeder cables. Where the tracks run close to the elevated structures, they are also heavily bonded to this structure in a number of places so as to increase the conductivity of the return circuit. The rails used on the surface railway weigh generally about 100 pounds per yard, and a large number of the joints are electrically welded, giving a conductivity of 100 per cent.

Electrical Developments on the Steam Railroads Entering New York City.—The New York Central Railroad decided several years ago to change its motive power from steam to electricity within the limits of the City of New York and for some distance beyond this limit. This electrification will extend from the Grand Central Station to White Plains on the Harlem Division, and to Croton on the Hudson River Division, and will comprise about 300 miles of single track. The work was begun in 1903 and is to be completed in 1908.

Direct current at 600 volts will be used for operating the electric locomotives and motor cars which have been especially designed for this work. These electric locomotives are planned to develop 2,200 horse power at their normal rating and to have maximum capacity of 2,800 horse power. At the 600 volts pressure used, these powers represent about 3,060 and 4,000 amperes respectively.

The electric power is to be generated as three-phase alternating currents in two main power stations and is to be distributed from 8 sub-stations as direct current. The total capacity of the two power stations combined is to be 40,000 kilowatts, with provisions for an ultimate increase of 60,000 kilowatts.

A third rail will be used for the positive working conductor, augmented by large auxiliary copper feeders. The service

rails, together with copper cables when necessary, will be used for the return circuit.

The New York, New Haven and Hartford Railroad Co. is electrifying a part of its system leading out from New York City, and has adopted single phase alternating current for its motive power. Since, however, it uses the Grand Central Station, in common with the New York Central Railroad, for its New York terminal, its motor equipment has been designed to operate also on the direct current supply of the latter road, where the common tracks are used. The outcome of this new development will be of great interest.

The Pennsylvania Railroad is also building a large terminal station in the heart of New York City, with tunnels extending completely across the city, and under the two rivers, connecting its lines in New Jersey and Long Island. Direct current at 650 volts will be used for the entire terminal service. The current distributing system to the trains will be similar to that of the New York Central Railroad, namely a third rail for one conductor and the service rails for the return conductor, augmented by copper feeder cables. Very large amounts of current will be required for this service.

ELECTROLYTIC CONDITIONS IN NEW YORK CITY.

The electric railways which were operated on Manhattan Island before 1903 were all double trolley conduit roads, which do not give rise to stray currents, and therefore do not form a source of danger to underground metals. Hence, notwithstanding the enormous amounts of currents used for electric traction in Manhattan, there has been practical immunity, in the past, from electrolytic damage.

The Manhattan Elevated Railway has been using a grounded return system only since 1903, and the Subway was opened in 1905, and no experience with Electrolysis due to stray currents from these systems has yet been made public.

The following statement, however, was made by Prof. George F. Sever, before the International Electrical Congress in St. Louis in 1904:

"The Manhattan Elevated Road uses its structure completely

bonded, its service rails completely bonded, and a large amount of return feeders, something like six or seven million cir. mils, to get its current back without causing trouble to its own and other conductors. In spite of all these precautions, there are still thousands of amperes coming back on its cable sheaths as well as those of other companies. It has been drawn to the attention of the city officials for their recommendation, as there is at times a higher potential than twenty-five volts between the end of the line and the nearest sub-station, which is the maximum fixed by the city rules."

It may be stated at this point that the only regulation in force in the City of New York for the protection of underground metals from Electrolysis is the following *worthless* provision, which is taken from the "Rules and Regulations" of the "Department of Water Supply, Gas and Electricity" for 1904:

"For the diminution of electrolytic corrosion of underground metal work, ground return wires must be so arranged that the difference of potential between the grounded dynamo terminal and any point on the return circuit will not exceed *twenty-five volts*" [!]

In the Bronx and the adjoining territory, where the single trolley and grounded rail return are used, considerable difficulty from Electrolysis has been experienced. Mr. A. A. Knudson reported the results of an electrolytic survey, which he made in New York City, in a paper read before the American Institute of Electrical Engineers in October, 1898. In this paper, Mr. Knudson states that he found considerable current in the gas and water pipes in the section of New York above the Harlem River, and gives the results of a great many voltage measurements between the rails, and the sewer pipes, the gas pipes, and the pillars of the elevated structure. He also states that in one location, where the rails are positive to the pipes, the bottoms of the rails were in some case so badly corroded that for several feet back from the ends these bottoms were cut down to knife edges; the tie rods which keep the rails in position were also found so eaten that the middle portion was missing.

In Brooklyn, where the single trolley with grounded rail

return is also used, considerable trouble from Electrolysis has been experienced. The stray currents from the Brooklyn system have even found their way into the pipes of Manhattan Island by way of the Brooklyn Bridge and the East River. A number of tests in this connection were made in Brooklyn and in Manhattan by Mr. A. A. Knudson, and some of these are recorded in a paper on the "Corrosion of Metals by Electrolysis," which is published in vol. 3, 1903, of the transactions of the American Electro-Chemical Society. The following is an abstract of a part of this paper:

It has been known for some years that pipes in the Brooklyn Navy Yard had been destroyed from time to time by Electrolysis. The potential difference between points on the sides of the Yard near Flushing Avenue and Navy Street, and a point nearest the power-station has been found to be from 20 to 25 volts. The railway company suggested that the damage caused to the underground pipes was not due to their currents, but was caused by the Navy Yard's own electric light and power circuits. The question remained uncertain until the day of the late President McKinley's funeral, when the Kent Avenue power-station, as well as all others in the country, closed down for five minutes. It occurred to some of the engineers of the Yard that it would be a good plan to make a few tests at that time, and this was done while the lighting and power circuits were running, and the railway power-station closed down. It was found that the voltmeter needles remained at zero at every test that was made, proving conclusively that the currents causing the damage emanated from the railway power-station.

Several water and gas mains have burst in Brooklyn, owing to Electrolysis. The following are a few instances: On July 14, 1899, an 8-in. water main burst in Flushing Avenue, near Classon Avenue. All the characteristics of Electrolysis were found upon this section of pipe, viz., the soft state of the iron in several places which was reduced to a condition of graphite, easily shaved with a pocket-knife. The voltmeter readings showed it positive to the rails, and it was also in wet soil. This pipe was of the Scotch iron make. Subsequently to the bursting of this main at this point, there have been

three other failures upon the same pipe in this street within short distances of each other.

The next is a 6-in pipe, and represents a clear case of Electrolysis. This was taken from Wallabout Place near Washington Avenue, a short distance from the canal. This pipe was positive to rails on Washington Avenue, positive to canal, and positive to gas mains in the same street. The highest reading found was 5.9 volts positive to rails.

A few years ago an impression prevailed that underground mains in Brooklyn were immune from Electrolysis, and it was thought that there was something about the Scotch iron mains which resisted electrolytic action. The theory was advanced that a thin "silicious compound" was formed over the surface of the Scotch pipes in the process of casting, and that this material insulated the pipes and made them immune to Electrolysis. In view of the fact that many failures of pipes in Brooklyn have occurred since 1899, due to Electrolysis, it is clear that the above reasons as to immunity will not stand.

In a discussion of Electrolysis before the International Electrical Congress at St. Louis in 1904, Mr. Bancroft Gherardi, Chief Engineer of the N. Y. and N. J. Telephone Co., made the following statement :

"One of the functions of my department is taking precautions against Electrolysis trouble on our cables, and in that connection the bulk of our work has been in Brooklyn, on account of our very large underground plant there and the great extent of the overhead trolley system. It is not unusual for us to have to take care of currents as great as 200 or 300 amperes at a single point on our system. This shows that the aggregate amount of currents that our system is carrying back to the power-houses amounts to thousands of amperes. There is a certain expense in connection with this work which is quite appreciable, and there still remains, after everything is done that we can do, a certain amount of trouble which is real trouble. The discussion of the responsibility for such trouble and expense is one that it seems to me beyond the scope of this section and I shall not touch on it here."

THE NEW ENGLAND WATER WORKS ASSOCIATION

in December, 1905, held a

"TOPICAL DISCUSSION ON ELECTROLYSIS,"

and the following are some remarks made at this discussion by Mr. Wm. E. Foss, Division Engineer of the Metropolitan Water Works of Boston:

"*Mr. President and Gentlemen:*—These specimens that Mr. Brooks has thoughtfully brought here for our inspection direct our attention to the difficulty of detecting injury to cast-iron pipes from Electrolysis, by a visual inspection only. It is usually easy to see the effects of Electrolysis on a lead, steel, or wrought-iron pipe from a rather careless examination, but the injury is found on the cast-iron pipes only by a very careful examination with a testing hammer or a knife. If the pipe is of lead, steel, or wrought iron, the metal is usually completely eaten away, leaving a visible pit or hole, but if of cast-iron, the iron is removed without destroying the form of the pipe which remains perfect, although the remaining substance is a soft material, like carbon, which can be easily cut with a knife or chipped with a testing hammer.

"A while ago, I had occasion to examine a 48-in. pipe line for electrolytic injury, and was unexpectedly detained at the office until after the workmen had completed the excavation. As I did not appear at the appointed time, the foreman examined the pipe, and telephoned to me, reporting that he had looked the pipe over very carefully and found it as good as new, with no evidence of any injury. He was directed to keep the excavation open, and when a careful inspection of the pipe was made with a testing hammer, a large number of deep pits were found in it.

"An interesting feature in connection with Electrolysis is that no way has yet been discovered to entirely prevent the action where the single trolley electric railway is in operation, although investigations of the process have been made during the past ten or fifteen years.

"Fairly good results have been obtained by bonding telephone cable sheaths to the rails or return wires, to protect

them. A complete knowledge of the electrical conditions existing at the time the bonds are connected is necessary in order to properly locate them, and continual inspections are necessary after they are connected, to detect the continually occurring changes in electrical conditions as soon as they take place, so that the necessary relocation of the bonds may be made. An objection to this method of protection is that it causes increased action on the other structures buried near the cables. An example of the damage caused in this way is given in the photograph, Plate II [not reproduced here], which shows a 6-in. hydrant pipe which burst while the hydrant was in use during the fire which destroyed the Academy of Music in Chelsea, on January 11, 1905. This break was due to the disintegration of the iron by Electrolysis at the point where it crossed under a telephone cable which had been bonded to the railway return for protection.

"After bonding, the cable is actually a portion of the street railway return system, and on account of being buried several feet below the surface in the damp ground near other structures, is more likely to cause Electrolysis than a rail located on the surface. As much as 500 to 700 amperes is drained from the cables over some of the bonds.

"Attempts have been made in a few places to protect the water and gas pipes from Electrolysis by bonding them to the rails, but the results have not been entirely satisfactory. In two cities, where the pipes were bonded to the rails about ten years ago, the pipes have remained positive to the rails in some districts, the injury to service pipes has continued, and it has recently been necessary to employ experts to investigate the electrical conditions in both places. In one of the cities some of the bonds were located in the negative districts and delivered electricity to the pipes instead of draining off that already on the pipes as intended. The result of making the pipe system a part of the electric railway return system has been to cause enormous currents to flow over some of the pipes. It has been reported that over 3,000 amperes is flowing on a 12-in. gas pipe in one of the cities, and that the pipe is perceptibly warmed by the current.

"It is a much more difficult problem to protect a pipe system

than it is to protect a telephone system by bonding, on account of its interwoven network of mains and services, large extent, large surface contact with the earth, and uncertain joint resistances. To attempt to protect all of the underground structures by bonding would necessitate the bonding of all of the structures, and of the adjacent parts of each structure together at many points, and the draining of the entire structure to the railway return through a booster. That is, to completely protect the structures by this method, each structure must be made negative to every other structure, which is evidently impossible. The nearest we could approach to this condition is to maintain all the structures at the same potential, and this is practically impossible.''

THE AMERICAN WATER WORKS ASSOCIATION.

unanimously adopted, in 1901, the following

REPORT OF SPECIAL COMMITTEE ON ELECTROLYSIS.

''Your Special Committee on Electrolysis, appointed to make recommendations for the guidance of the Association, in dealing with the problem, and to formulate, for your approval, an expression of the attitude of the Association on this question, respectfully begs to submit herewith its report:

''The following facts are established:

1. ''A very large number of mains and service pipes have been already actually destroyed by the stray return currents of electric railways operating under the single trolley system, many instances of such destruction of pipes by these currents having been reported from practically every city where the single trolley system has been in use for any considerable length of time. Even where the action is too slow to be immediately discovered, the life of the mains and service pipes is inevitably greatly shortened and their value thereby necessarily proportionately decreased.

2. ''In the single trolley system, no matter how large the capacity of the return feeders, nor how good the bonding of the rails, and even when the continuous rail is used, some electric current will, under the law of divided circuits, flow

along the water-pipes, the amount of this current bearing the same proportion to the total current used, that the conductivity of the return path of which the water-pipes form a part, bears to the total conductivity of all the return paths offered to the current. As neither the rails nor the pipes can practically be insulated from the soil in which they are laid, the proportion of current conveyed by the pipes is considerable, even with the best track-bondage known to modern science, including the welded joint.

3. "The electrical current, once on the pipes, must leave them to return to its source, the generator, and wherever the current leaves the pipes to pass through the soil, the pipes are damaged.

4. "Electrolysis also results from differences in potential between water-pipes and any other underground metal conductor such as gas-pipes and as long as the return current is not entirely removed from the earth, such action will continue.

5. "The extent of the electrolytic injury at any point is directly proportionate to the number of amperes of current leaving the pipe. The smallest measurable difference of potential is sufficient to produce Electrolysis.

6. "A cast-iron water-main is not a continuous electric conductor, and its joints offer very much higher resistance than an equal length of the plain pipe.

7. "The inevitable effect of any resistance at the joints is to cause a part of the current carried on the pipes to be shunted around the joint either through the soil on the outside or through the water on the inside, or by both paths.

8. "Wherever the current leaves the pipe to pass around the joint, either outside or inside, or both, the pipe is injured. The action of a fraction of an ampere flowing around successive joints will in time do great aggregate damage to any cast-iron main on which it flows.

"Your committee is convinced, after careful consideration of reliable data on the subject, that there is no known practical method by which owners of underground pipes can protect them against electrolytic injury from single trolley

currents, but that there are two methods of operating electric railways by which the return currents can be kept out of the ground; namely, the conduit system as in use in New York City and in Washington, D. C., and the double overhead trolley system as operated in Cincinnati, Ohio, and on suburban lines in the District of Columbia.

"The conduit system is more expensive to construct, and is peculiarly adapted to the larger cities. The first cost of installing a double trolley system would be a little greater than that of a single trolley system for the same service; while the cost of converting an existing single trolley system to a double trolley system would be trifling, as compared with the enormous interests endangered by the single trolley current.

"Ten years' experience with the double trolley in Cincinnati proves that that system is entirely practical, possesses many advantages over the single trolley, is more economical in operation and maintenance, and that it completely stops the injury to the pipes.

"Your Committee, therefore, respectfully makes the following recommendations:

1. "Street railway companies should be compelled, as are electric light companies, and all other electric power companies, to provide a complete metallic circuit for their current, absolutely insulated from the rails and ground. This will keep the return currents out of the ground and off the pipes, and can be accomplished either by the conduit system or by the double overhead trolley system.

2 "No connections by which a current is carried to the pipe, or induced to flow thereon, should be allowed from pipes to rails, or to other return conductors; and no other alleged remedy which permits the mains to carry any portion of the return current should be countenanced by those in charge of water works plants. Even the failure to prohibit or to protest against such connections might be construed by law to be a tacit consent on the part of the water works management to the use of the pipes as conductors, and might relieve the electric railway company from responsibility for the injury which

would inevitably result if the mains were allowed to convey current.

"In the further discharge of the duties for which it was appointed, your committee respectfully submits for your approval the following preamble and resolutions, as an expression of the attitude of this Association on the question of Electrolysis:

"*Whereas*, The report of the Special Committee on Electrolysis shows that wherever the single trolley system is in use, a portion of the return electric current will flow on the water pipes, and that whenever water pipes becomes positive to rails or gas pipes or other underground metal structures, the water pipes are injured; and that whenever water mains, whether positive or negative to the rails, convey electric current, they are liable to injury thereby, near the joints; and

"*Whereas*, It further appears from the said report that there is no known practical method by which owners of water pipes can protect themselves against electrolytic injury resulting from the operation of single trolley cars, but that electric railways may, by means of the conduit system or of the double overhead trolley system, be operated successfully and economically and without any injury to the water pipes; now, therefore, be it

"*Resolved*, That the American Water Works Association, as a national organization, herewith unanimously maintains that street railways have no right to so operate their cars as to cause injury and destruction to water pipes; and be it further

"*Resolved*, That street railways now operating under the single trolley system ought to be required to remove their return current from the ground, and that if they continue to operate by current transmitted from the power station to motors on the cars, they should be required to provide a complete metallic circuit of sufficient capacity to convey all the current, and in a manner absolutely to insulate it from the rails and from the earth."

(Signed) DABNEY H. MAURY,
G. H. BENZENBURG,
J. WALDO SMITH,
Special Committee on Electrolysis.

Section III.

Electrolysis in Great Britain.

It may facilitate the endeavor to apply British experience to American conditions, if this Section be prefaced with a brief description of the connection between the National Government and municipal and public undertakings in the United Kingdom. Great Britain has what may be called a central financial government of public utilities. The broad financial control of all municipal and public undertakings centres in Parliament. Parliament holds the general purse strings, not only of the Nation, but also of the local authorities, and of all public franchise undertakers throughout the United Kingdom.

What are known in America as public franchises, are generally described in Great Britain as "Parliamentary powers"; and the right to grant such powers or franchises is vested solely in Parliament. British municipalities cannot grant such public rights to others, nor can they even supply themselves with gas, water, electricity, or similar public necessities or conveniences, without Parliamentary sanction. Theoretically, a British municipality is on precisely the same basis with a private citizen when seeking Parliamentary powers for public service undertakings.

This Parlimentary control over municipal and public undertakings is exercised both through direct Acts of Parliament and through the medium of the Departments of State known, respectively, as the Board of Trade and the Local Government Board, the Presidents of which are Cabinet Ministers.

In general, the British system operates as follows:

A municipality, or an association of individuals, applies to Parliament for power (for instance) to construct and operate an electric tramway in specified thoroughfares. If this application has been legally advertised, so that all affected thereby have received proper notification to enable them to oppose the application, and if all other Standing Orders of Parliament have been duly complied with, the application or Bill is admitted to what is called the Committee Stage. Then a

Commons' Committee and a Lords' Committee, acting independently, take evidence and hear witnesses and counsel *pro* and *con* the Bill, which must be approved by both of these Committees before it is recommended to Parliament for passage.

If the Bill passes both Houses and becomes an Act, it will *inter alia* fix the amount of money that may be expended under the Act, and will place the enterprise under the jurisdiction of the Board of Trade or of the Local Government Board. That is to say, Parliament delegates certain regulative powers to one or both of these two Departments of State until the expenditure authorized has been exhausted. It is then necessary for the Undertaking to seek further Parliamentary power to raise new capital for the prosecution of the enterprise. Upon each such occasion, Parliamentary Committees, with the aid of the Board of Trade and the Local Government Board, investigate the manner in which the Undertaking has fulfilled its responsibilities, and hear witnesses and counsel *pro* and *con* the new application. It is the practice of Parliament to restrict the financial powers granted upon any one occasion so that public service undertakers must reappear before Parliament, at reasonably frequent intervals, to demonstrate that they are using their privileges fairly in the interests of both public and shareholders, and to ensure that the degree of supervision delegated to the Board of Trade and to the Local Government Board, during the interregnum, is effective and sufficient.

General electric lighting acts were enacted by Parliament in 1882 and 1888, and in 1899 there was enacted a further general Electric Lighting (Clauses) Act "incorporating in one Act certain provisions usually contained in Provisional Orders made under the (previous) Acts relating to Electric Lighting."

Section 77 of this 1899 Act is as follows:

"The Undertakers shall be answerable for all accidents, damages, and injuries happening through the act or default of the Undertakers, or of any person in their employment by reason of or in consequence of any of the Undertakers' works, and shall save harmless all authorities, bodies, and persons by whom any street is repairable, and all other authorities,

companies, and bodies collectively and individually, and their officers and servants, from all damages and costs in respect of those accidents, damages and injuries."

Gas, water, telephone, railway signal and other affected interests, feel and are sufficiently safe-guarded by the above broad protective clause, insofar as electric lighting undertakings are concerned; and, on the other hand, this clause is considered practicable by the electric lighting undertakings, who are willing to conduct their operations subject thereto.

The fact that this mutually satisfactory basis has been so readily reached between the electric lighting interests and the other statutory undertakings, is due to the invariable use in electric lighting of insulated metallic returns.

But when we come to the question of tramways or other undertakings using large currents of electricity with uninsulated returns, or even with the earth as a return, a new condition is presented which requires special protective measures; and it is this phase of the problem with which we are now concerned.

Owing to complaints of telephonic and other electrical disturbances, and to apprehensions regarding the destructive effect of Electrolysis upon gas and water mains following the extensive introduction of electric tramways, a Joint Committee of Lords and Commons was appointed in 1893

"to consider and report whether the grant of Statutory Powers to use Electricity ought to be qualified by any prohibition or restriction as to Earth Return Circuits, or by any provisions as to Leakage, Induction, or similar matters; and, if so, in what cases and under what conditions. And, if the Joint Committee is of opinion that any such prohibition, restriction or provision should be enforced, to settle the necessary Clauses."

The Report of this Joint Committee, together with the proceedings, minutes of evidence, etc., extending to some 300 pages of closely printed foolscap,* was submitted July 13th, 1893. The Report proper is appended to this Statement, and is marked *Exhibit A*.

*This Parliamentary "Blue Book," which is filled with the evidence and arguments desired by Mr. Beal regarding this Electrolysis problem, will be furnished by the Association to interested Members at one dollar per copy.

The next Governmental step in the general control of electric tramways was the establishment by the Board of Trade of general Tramway Regulations giving effect to the recommendations of the Joint Committee. These Board of Trade Regulations are appended to this Statement, and marked *Exhibit B.*

The third and final *general* step in the Parliamentary control of electric tramways was the drafting of a Model Tramways Bill. This Model Bill, as its name implies, is merely an official pattern drafted for the guidance of committees and promoters. It contains the various Standard Clauses framed to give the proper legal effect, when incorporated in specific Bills, to the general Acts and Regulations defining and restricting the Parliamentary powers conferred upon electric tramway undertakings.

As this Model Bill epitomises authoritatively the general privileges as well as the general responsibilities of British electric tramway undertakings, it is appended to this statement, marked *Exhibit C;* and especial attention is directed to the sub-division entitled "Use of Mechanical Power," being Sections 19-25 inclusive.

We have now traversed the history of Parliamentary general control of electric tramways in the United Kingdom, insofar as damage from Electrolysis is concerned.

FIRSTLY, the appointment of a Joint Committee from both Houses of Parliament to consider and report upon the question of Protective Clauses. (See Exhibit A, and Parliamentary "Blue Book").

SECONDLY, the drafting of specific Regulations, giving effect to the recommendations of this Committee, by the Department of State (the Board of Trade) responsible for such control of electric tramway undertakings. (See Exhibit B.)

THIRDLY, the establishment of a Model Tramways Bill, embodying *inter alia* these Board of Trade Regulations, to which all specific applications for Parliamentary powers to conduct tramway operations must substantially conform, before they can pass the Committees of either House. (See Exhibit C.)

It will be seen, therefore, that Parliament has established

a general system governing electric tramways, whereby all other statutory undertakings in the United Kingdom receive automatically, as it were, such protection as is afforded by the Board of Trade Regulations. Hence, as far as Great Britain is concerned, the first question is whether these Board of Trade Regulations are meant to, and do afford effective protection to gas and other pipes from damage by Electrolysis.

Clause (3) of Section 20 of the Model Tramway Bill (see Exhibit C) says:

> "The Electrical Power shall be used only in accordance with the Board of Trade Regulations, and in such Regulations provisions shall be made *for preventing fusion or injurious electrolytic action of or on gas or water pipes* or other metallic pipes, structures or substances and *for minimizing as far as is reasonably practicable* injurious interference with the electric wires, lines and apparatus of other parties and the Currents therein, whether such lines do or do not use the earth as a Return."

Parliament has thus expressly instructed the Board of Trade to impose Regulations upon electric tramway undertakers "for preventing fusion or injurious electrolytic action of or on gas or water pipes," whereas they are required only *to minimize as far as is reasonably practicable* injurious interference with electric lines and currents.

This discrimination is further brought out in Clause (4) which contains no further reference to fusion or Electrolysis, but which specifically exempts tramway undertakers from consequences due to electrical *interference*, provided they conform to the Board of Trade Regulations. Clause (5) still further emphasizes this discrimination. It is clear, therefore, that Parliament expects the Board of Trade to impose tramway regulations that will give gas and water pipes practical immunity from fusion or Electrolysis.

On this expectation that the Board of Trade Regulations are (or should be) an effective protection from fusion and electrolytic action, these Clauses (3) and (4) are construed to relieve tramway undertakers of all liability for damage due to fusion or Electrolysis, as well as to electrical interference, provided their operations are conducted, as they must be, in

accordance with these Board of Trade Regulations. Therefore, unless negligence be proven, tramway undertakers are not liable at Common Law for any damage sustained by other statutory undertakings from these causes. In other words, so long as tramway undertakers conform to the Board of Trade Regulations, and conduct their operations with reasonable care, they are legally exempted from responsibility for damage by fusion, Electrolysis, or electrical interference, consequent upon their operations.

The crux of the Board of Trade Regulations is Clause 7:

"When the return is partly or entirely uninsulated a continuous record shall be kept by the Company of the difference of potential during the working of the tramway between points on the uninsulated return. If at any time such difference of potential between any two points exceeds the limit of seven volts, the Company shall take immediate steps to reduce it below the limit."

As was inevitable, with this permissible potential difference of *seven* volts (the German Electrolysis Commission suggest a present limit of *one* volt), gas and water companies find that these Regulations will not and cannot prevent damage from Electrolysis.

Hence, the imposition of these Regulations has brought exemption to electric tramway undertakings, without bringing immunity to gas undertakings. Gas companies are, therefore, asking whether the cure is not worse than the disease; that is to say, whether the insufficient relief afforded them by the existing Board of Trade Regulations justifies the sacrifice of their common law rights to compensation for any damage to their property caused by another party?

Consequently, it is the usual thing to find applications for Parliamentary powers for new or extended electric tramways opposed in Committee by the local gas companies. This opposition invariably takes the form of an effort to secure a protective clause, making the tramway undertaking responsible at common law for any damage to gas pipes or appurtenances which can be brought home to them, notwithstanding the fact that they may have conformed in every particular to the Board of Trade Regulations.

The argument of the gas company in support of such a clause is somewhat as follows:

If these Board of Trade Regulations are effective, as Parliament clearly intended they should be, then no damage to gas and water pipes will ensue, and no additional responsibility will accrue to the electric tramways under the proposed clause. If, on the other hand, the present Board of Trade Regulations are not effective, as is undoubtedly the case, then, pending the effective revision of these Regulations, gas companies shall not be deprived of their common law rights to compel those who have damaged them to repair such damage. It is not merely the lawful privilege, but it is *the compulsory duty* of gas companies to maintain their pipes in constant service in the public streets. They have no option in the matter; failure will result in the confiscation of their property. Nor is there any legitimate reason why the public danger and cost of gas supply should be largely increased, in order that electric tramway undertakers may obtain greater profit from their operations. Nor should gas consumers be obliged to pay more for their gas in order that the fares of tramway passengers may be reduced: surely, each service must rest upon its own bottom. In view of the present state of the art of electric traction, *positive* precautions can and should be adopted by urban electric tramways to prevent electrolytic destruction of street mains and services; and such half-way measures as the Board of Trade Regulations should represent merely the irreducible minimum of precaution, without which no electric tramways may operate, and should not confer wholesale exemption from responsibility for damage consequent upon such operations.

In certain cases such protective clauses, re-establishing their common law rights, have been obtained by gas companies, due largely to unquestionable evidence of actual electrolytic damage already sustained in these cases. But, owing to the comparatively limited and brief experience of electric traction in Great Britain, such damage has not yet generally asserted itself by external evidence of destruction. Moreover, gas companies have not always promoted the same kind of protective clause;

and, as the Board of Trade has been made specifically responsible for regulations which will prevent fusion and Electrolysis, while not imposing impracticable restrictions upon the tramways undertakings, Parliament has decided that any further protection required by gas companies must be obtained by inducing the Board of Trade to remedy the insufficiency of their present Regulations, instead of by the insertion of special protective clauses in individual Acts granting Parliamentary powers for electric traction.

Now, as to what changes or new regulations are necessary to ensure the immunity of street mains and services from damage by Electrolysis.

Although great *improvement*—as at Bristol, Glasgow and elsewhere—can be effected in electrolytic conditions by the thorough bonding of rails and such construction of track foundations as to increase as much as practicable the resistance between the rails and earth, in connection with a properly balanced system of limiting the fall of potential in rail returns by the application of return feeders (or "suckers") to different points of the line,* it will, nevertheless, not be gainsaid that the best method of ensuring practical immunity from electrolytic damage due to stray currents is the use of completely insulated circuits for the electric current. Indeed, in view of the very small difference of potential at which electrolytic damage will take place, this is universally conceded to be the *only* practical method which will or can prevent damage by Electrolysis. Nor is there any unreasonable practical or financial difficulty in conforming to such conditions in urban communities. This is shown by the fact that an important proportion of urban electric traction is already operated with insulated metallic returns, and there seems little doubt that this system must eventually become general in all large centres of population. Hence, the wisdom of anticipating such

*For early descriptions of this *mitigating* method see three interesting Papers by Messrs. Parshall, Trotter and Cardew, respectively, read and discussed April 28th, 1898, at the (British) Institution of Electrical Engineers; also, the discussions of Profs. Perry, Ayrton, Thompson and Swan, favoring an insulated circuit—both for the safety of other interests and for reasons beneficial to the railways. For recent descriptions of this return feeder system see the German Section of this Report.

conditions before wholesale destruction has been meted out to gas and water distributing systems.

In default of an effective alternative, it is clearly inadvisable for gas companies generally to resign themselves to the abrogation of their common law rights to compensation for (electrolytic) damage, in exchange for the imposition of tramway regulations which fall short of the compulsory use of completely insulated conductors for the return current. If electric tramways are required to conduct their operations in accordance with the best practical means of preventing damage to other statutory undertakings (i. e., to use insulated metallic returns), then, in return for such effective precautions, gas companies may prudently consent to the relief of tramway undertakings from all responsibility for damage from stray currents, not due to negligence or lack of reasonable care in their operations. But until such reasonable protection can be legally secured, gas companies, in the interest of the public as well as of shareholders, must meet any ineffective measure of relief (such as the present Board of Trade Regulations) by insisting upon their common law rights to compensation for any damage that ensues from such insufficient protection.

As matters now stand in Great Britain, Parliament has virtually invited gas and water companies to induce the Board of Trade to alter its Regulations so as to afford practical immunity from electrolytic damage. It is, therefore, to be expected that the gas and water companies will make concerted representations to the Board of Trade looking to the compulsory adoption by tramway undertakings—at least in large urban communities—of completely insulated metallic conductors for the return current, in consideration of exemption from liability for electrolytic damage.

Concerted action to secure the proper revision of the Board of Trade Regulations governing electric tramway return currents must lead to far better practical results in Great Britain than can ever be obtained by the attempts of individual gas or water companies to maintain their common law rights to compensation for such damage as can be legally brought home to the electric tramways. For instance, in a town where there are several distinct tramway undertakings, how is it possible

to bring home to the specific offender, with legal certainty, any damage occasioned by Electrolysis? And, even if one could get an occasional pipe replaced, how would that compensate for the loss of gas and for the labor and expense of locating and proving the damage, not to speak of such possible consequences as fire, explosion and asphyxiation? Manifestly, an ounce of effective prevention is worth, in this case, tons of incomplete cure; and perhaps the most real benefit of agitating for the preservation of common law rights in Great Britain is that it tends to make the tramway companies more careful in their present construction and operation, and may encourage the Board of Trade more speedily to revise its Regulations so as to give gas and water companies and others effective protection from Electrolysis.

Great Britain—Exhibit A.

ELECTRIC POWERS (PROTECTIVE CLAUSES).

The Joint Select Committee appointed to join with a Committee of the House of Lords to consider and report whether the grant of Statutory Powers to use Electricity ought to be qualified by any prohibition or restriction as to Earth Return Circuits, or by any provisions as to Leakage, Induction, or similar matters, and if so, in what cases and under what conditions:—Has considered the matters to them referred, and has agreed to the following Report:—

The Committee have taken evidence from Sir Courtenay Boyle, K. C. B., from Mr. Preece, Engineer-in-Chief and Electrician to the Post Office, from Major Cardew, Electrical Adviser to the Board of Trade, and the Astronomer Royal.

Counsel appeared before them on behalf of—

1. The National Telephone Company.
2. The Railway Companies.
3. Electric Tramway Companies, and Electric Underground Railway Companies.
4. Electric Lighting Companies.
5. Municipal Corporations, England and Scotland.
6. Tramway Institute of Great Britain and Ireland.
7. Gas and Water Companies.

Her Majesty's Postmaster General was also represented, but not by Counsel.

The Committee has heard all the witnesses tendered by the several parties, and has agreed upon the following Clause, to be inserted in all Bills and Provisional Orders which authorize the Undertakers, other than Electric Lighting Undertakers, to use large electric currents, viz.:

CLAUSE.

To be inserted in all BILLS and PROVISIONAL ORDERS which authorize any Company, Corporation, or Person, collectively referred to as "the Undertakers," to use larger Electric Currents for other than Electric Lighting purposes.

(*Some modifications of Form may be required to meet the circumstances of particular cases.*)

(1.) The Undertakers shall, in the use of electric power under the provisions of this Act [Order], employ either insulated returns or uninsulated metallic returns of low resistance. [This Clause not to apply in the case of railways, tramways, or tramroads in which the motive power is entirely self-contained.]

(2.) The Undertakers shall take all reasonable precautions in constructing, placing, and maintaining their electric lines and circuits, and other works of all descriptions, and also in working their undertaking so as not injuriously to affect, by fusion or electrolytic action, any gas or water pipes, or other metallic pipes, structures, or substances.

(3.) The exercise of the powers by this Act [Order] conferred with respect to the use of electric power, shall be subject to the regulations set forth in the Schedule to this Act [Order], and to any regulations which may be added thereto or substituted therefor, respectively, by any order which the Board of Trade may, and which they are hereby empowered to make from time to time, as or when they may think fit, for regulating the employment of insulated returns or of uninsulated metallic returns of low resistance, for preventing fusion or injurious electrolytic action of or on gas or water pipes, or

other metallic pipes, structures, or substances, and for minimizing, as far as is reasonably practicable, injurious interference with the electric wires, lines, and apparatus of other parties and the currents therein, whether such lines do or do not use the earth as a return.

(4.) The Undertakers using electric power contrary to the provisions of this Act [Order], or to any of the regulations set forth in the Schedule to this Act [Order], or to any regulation added thereto or substituted therefor by any order made by the Board of Trade under the authority of this Act [Order], shall, for every such offense, be subject to a penalty not exceeding *ten* pounds, and also in the case of a continuing offense to a further penalty not exceeding *five* pounds for every day during which such offense continues after conviction thereof: Provided always, that, whether any such penalty has been recovered or not, the Board of Trade, in case in their opinion the Undertakers in the use of electric power under the authority of this Act [Order], have made default in complying with the provisions of this Act [Order], or with any of the regulations set forth in the Schedule to this Act [Order], or with any regulation which may have been added thereto or substituted therefor as aforesaid, may by order direct the Undertakers to cease to use electric power, and thereupon the Undertakers shall cease to use electric power, and shall not again use the same, unless with the authority of the Board of Trade, and in every such case the Board of Trade shall make a special report to Parliament notifying the making of such order.

(5) The Undertakers shall take all reasonable and proper precautions in constructing, placing and maintaining their electric lines, circuits, and other works of any description, and in using their electric lines, circuits, and other works, so as not injuriously to interfere with the working of any wire, line or apparatus, from time to time used for the purpose of transmitting electric power, or of telegraphic, telephonic, or electric signaling communication, or the currents in such wire, line or apparatus. Provided always that the Undertakers shall be deemed to take all such reasonable and proper precautions as aforesaid, if and

so long as they adopt and employ, at the option of the Undertakers, either such insulated returns or such uninsulated metallic returns of low resistance, and such other means of preventing injurious interference with the electric wires, lines, and apparatus of other parties, and the currents therein, as the Board of Trade shall direct, and in giving such directions the Board shall have regard to the expense involved, and to the effect thereof upon the commercial prospects of the undertaking. Provided also that at the expiration of (   ) years from the passing of this Act [Order] nothing in this sub-section shall operate to give any right of action in respect of, or to protect any electric wires, lines, or apparatus, or the currents therein, unless in the construction, erection, maintaining, and working of such wires, lines, and apparatus, all reasonable and proper precautions, including the use of an insulated return, have been taken to prevent injurious interference therewith, and with the current therein, by or from other electric currents. If any difference arises between the Undertakers and any other party with respect to anything in this sub-section contained, such difference shall, unless the parties otherwise agree, be determined by the Board of Trade, or at the option of the Board by an arbitrator to be appointed by the Board; and the costs of such determination shall be in the discretion of the Board, or of the arbitrator, as the case may be.

(6) Nothing in this section shall apply to the use of any electric line, circuit, or work of any company, corporation, or person authorized by Act of Parliament, or Provisional Order confirmed by Parliament, to supply energy for electric lighting purposes, so far as such use is limited to such purposes.

The Committee has also agreed upon the following Resolutions in the nature of Recommendations, viz.:

(1.) The Committee having regard to the evidence before them are of opinion that it is not in the present state of electrical science to the interest of the public to insist upon electrical tramways using an insulated return conductor, and that such insistance would retard the development of electric traction.

(2.) The chief objections which have been urged before the Committee to an uninsulated return conductor are, first, the interference by leakage and induction with telephones;

secondly, the interference by leakage and induction with railway signals; thirdly, the damage to systems of gas and water pipes by the action of leakage currents.

(3.) They are of opinion that the best-known means of overcoming the first of these disturbances, is by providing an insulated return conductor for the telephones, and they have the less hesitation in recommending this course as the evidence shows that telephone construction is already tending in this direction, and that better results are secured to the public by the use of a twisted metallic circuit insulated entirely from the earth.

(4.) The second objection deserves serious consideration on account of the danger to the public, but the Committee are of opinion that the disturbance may be remedied at comparatively small expense by the adoption of an insulated metallic return by the railway companies.

(5.) They consider that, although electric tramway and electric railway companies should be allowed to use the wheels of carriages and the rails to complete the electric circuit, the currents should be produced and used in such a manner as to mitigate as far as is practicable any injurious effect to telephonic communication.

(6.) The Committee are of opinion that it is desirable in every way to facilitate the use of complete insulated metallic circuits for telephones, and for this end they recommend that statutory powers be granted enabling telephone undertakers to lay their wires underground.

(7.) The danger from fusion or electrolytic action appears to the Committee to have arisen from a faulty system of constructing electric tramways, and they are of opinion that it can be reduced by improved methods of construction so as to be practically negligible.

(8.) The Committee therefore recommend that the Board of Trade shall, in virtue of the powers to be conferred upon them by each Act or Order, make regulations to secure the best system of working electric tramways and railways, having regard to the expense involved by the carrying out of such regulations, and to the effect thereof upon the commercial

prospects of the undertaking. The regulations to provide, *inter alia*,—

(*a.*) That a return conductor, if in contact with the ground, shall be of such section and resistance as to have no difference of potential sufficient to set up injurious leakage currents in the earth.

(*b.*) That, both with regard to the structure of the line and to the method of generation and use of the electrical current, everything shall be maintained up to the standard required by the Board of Trade; but, if the regulations are altered after the use of electric power on the line has been sanctioned, the Undertakers shall not be required to alter the structure or method of working of the line to conform to the more recent regulations, except for the public safety, or unless it shall be proved to the satisfaction of the Board of Trade that any system of metallic pipes or structures is being substantially injured by the action of electricity escaping from the conductors, or for purposes other than public safety or injury to pipes or structures which the Board may think right, provided that the alterations do not in such last case cause substantial additional expenditure.

(*c.*) That all such electrical tests shall be applied to the line by the Undertakers as the Board of Trade may think necessary, and that a record of these tests shall be kept for the information of the Board of Trade.

(*d.*) That the Board of Trade shall have all reasonable facilities for making any tests they may think necessary, in addition to those recorded by the Undertakers to enable them to secure the maintenance of satisfactory conditions.

(9.) That the Committee regards with apprehension a large extension of the system of overhead wires in crowded centres.

(10.) It appears to the Committee to be just that Undertakers proposing to use large currents should be required to give ample notice to those using small currents to enable them to protect themselves by insulation, and that with this view, and in reference to the Clause agreed upon, a period of two years may fairly be allowed to telephone and telegraph companies from the date of the passing of any Act [Order].

13 July 1893.

Great Britain—Exhibit B.

Regulations made by the Board of Trade under the provisions of Special Tramways Acts or Light Railway Orders authorizing lines on public roads; for regulating the use of electrical power; for preventing fusion or injurious electrolytic action of or on gas or water pipes or other metalic pipes, structures or substances; and for minimizing as far as is reasonably practicable injurious interference with the electric wires, lines, and apparatus of parties other than the Company, and the currents therein, whether such lines do or do not use the earth as a return.

FIRST MADE, MARCH, 1894.

REVISED, APRIL, 1903.

FURTHER REVISED, JULY, 1904.

DEFINITIONS.

In the following regulations—

The expression "energy" means electrical energy.

The expression "generator" means the dynamo or dynamos or other electrical apparatus used for the generation of energy.

The expression "motor" means any electric motor carried on a car and used for the conversion of energy.

The expression "pipe" means any gas or water pipe or other metallic pipe, structure, or substance.

The expression "wire" means any wire or apparatus used for telegraphic, telephonic, electric signaling, or other similar purposes.

The expression "current" means an electric current exceeding one thousandth part of one ampere.

The expression "the Company" has the same meaning as in the Tramways Act [Light Railways Order].

REGULATIONS.

1. Any dynamo used as a generator shall be of such pattern and construction as to be capable of producing a continuous current without appreciable pulsation.*

*The Board of Trade will be prepared to consider the issue of regulations for the use of alternating currents for electrical traction on application.

2. One of the two conductors used for transmitting energy from the generator to the motors shall be in every case insulated from earth, and is hereinafter referred to as the "line;" the other may be insulated throughout, or may be uninsulated in such parts and to such extent as is provided in the following regulations, and is hereinafter referred to as the "return."

3. Where any rails on which cars run or any conductors laid between or within three feet of such rails form any part of a return, such part may be uninsulated. All other returns or parts of a return shall be insulated, unless of such sectional area as will reduce the difference of potential between the ends of the uninsulated portion of the return below the limit laid down in regulation 7.

4. When any uninsulated conductor laid between or within three feet of the rails forms any part of a return, it shall be electrically connected to the rails at distances apart not exceeding 100 feet by means of copper strips having a sectional area of at least one-sixteenth of a square inch, or by other means of equal conductivity.

5. (*a.*) When any part of a return is uninsulated it shall be connected with the negative terminal of the generator, and in such case the negative terminal of the generator shall also be directly connected, through the current indicator hereinafter mentioned, to two separate earth connections which shall be placed not less than 20 yards apart.

(*b.*) The earth connections referred to in this regulation shall be constructed, laid, and maintained so as to secure electrical contact with the general mass of earth, and so that an electro-motive force, not exceeding four volts, shall suffice to produce a current of at least two amperes from one earth connection to the other through the earth, and a test shall be made at least once in every month to ascertain whether this requirement is complied with.

(*c.*) Provided that in placed of such two earth connections the Company may make one connection to a main for water supply of not less than three inches internal diameter, with the consent of the owner thereof and of the person supplying the water, and provided that where, from the nature of the soil

or for other reasons, the Company can show to the satisfaction of an inspecting officer of the Board of Trade that the earth connections herein specified cannot be constructed and maintained without undue expense the provisions of this regulation shall not apply.

(*d.*) No portion of either earth connections shall be placed within six feet of any pipe except a main for water supply of not less than three inches internal diameter which is metalically connected to the earth connections with the consents herein-before specified.

(*e.*) When the generator is at a considerable distance from the tramway, the uninsulated return shall be connected to the negative terminal of the generator by means of one or more insulated return conductors, and the generator shall have no other connection with earth; and in such case the end of each insulated return connected with the uninsulated return shall be connected also through a current indicator to two separate earth connections, or with the necessary consents to a main for water supply, or with the like consents to both in the manner prescribed in this regulation.

(*f.*) If the current indicator cannot conveniently be placed at the connection of the uninsulated return with the insulated return, this instrument may consist of an indicator at the generating station connected by insulated wires to the terminals of a resistance interposed between the return and the earth connection or connections. The said resistance shall be such that the maximum current laid down in Regulation 6 (i.) shall produce a difference of potential not exceeding one volt between the terminals. The indicator shall be so constructed as to indicate correctly the current passing through the resistance when connected to the terminals by the insulated wire before mentioned.

6. When the return is partly or entirely uninsulated, the Company shall in the construction and maintenance of the tramway (*a*) so separate the uninsulated return from the general mass of earth, and from any pipe in the vicinity; (*b*) so connect together the several lengths of the rails; (*c*) adopt such means for reducing the difference produced by the current between the potential of the uninsulated return at

any one point and the potential of the uninsulated return at any other point; and (*d*) so maintain the efficiency of the earth connections specified in the preceding regulations as to fulfill the following conditions, viz.:

(i.) That the current passing from the earth connections through the indicator to the generator or through the resistance to the insulated return shall not at any time exceed either two amperes per mile of single tramway line or five per cent. of the total current output of the station.

(ii.) That if at any time and at any place a test be made by connecting a galvanometer or other current indicator to the uninsulated return and to any pipe in the vicinity, it shall always be possible to reverse the direction of any current indicated by interposing a battery of three Leclanché cells connected in series if the direction of the current is from the return to the pipe, or by interposing one Leclanché cell if the direction of the current is from the pipe to the return.

In order to provide a continuous indication that the condition (i.) is complied with, the Company shall place in a conspicuous position a suitable, properly connected, and correctly marked current indicator, and shall keep it connected during the whole time that the line is charged.

The owner of any such pipe may require the Company to permit him at reasonable times and intervals to ascertain by test that the conditions specified in (ii.) are complied with as regards his pipe.

7. When the return is partly or entirely uninsulated a continuous record shall be kept by the Company of the difference of potential during the working of the tramway between the points on the uninsulated return. If any time such difference of potential between any two points exceeds the limit of seven volts, the Company shall take immediate steps to reduce it below that limit.

8. The current density in the rails shall not exceed 9 amperes per square inch.

9. Every electrical connection with any pipe shall be so arranged as to admit of easy examination, and shall be tested by the Company at least once in every six months.

10. Every line and every insulated return or part of a

return except any feeder shall be constructed in sections not exceeding one-half of a mile in length, and means shall be provided for isolating each such section for purposes of testing.

11. The insulation of the line and of the return when insulated, and of all feeders and other conductors, shall be so maintained that the leakage current shall not exceed one hundredth of an ampere per mile of tramway. The leakage current shall be ascertained daily before or after the hours of running when the line is fully charged. If at any time it should be found that the leakage current exceeds one half of an ampere per mile of tramway the leak shall be localized and removed as soon as practicable, and the running of the cars shall be stopped unless the leak is localized and removed within 24 hours. Provided that, where both line and return are placed within a conduit this regulation shall not apply.

12. The insulation resistance of all continuously insulated cables used for lines, for insulated returns, for feeders, or for other purposes, and laid below the surface of the ground, shall not be permitted to fall below the equivalent of 10 megohms for a length of one mile. A test of the insulation resistance of all such cables shall be made at least once in each month.

13. Where in any case in any part of the tramway the line is erected overhead and the return is laid on or under the ground, and where any wires have been erected or laid before the construction of the tramway in the same manner or nearly the same direction as such part of the tramway, the Company shall, if required so to do by the owners of such wires or any of them, permit such owners to insert and maintain in the Company's line one or more induction coils or other apparatus approved by the Company for the purpose of preventing disturbance by electric induction. In any case in which the Company withhold their approval of any such apparatus the owners may appeal to the Board of Trade, who may, if they think fit, dispense with such approval.

14. Any insulated return shall be placed parallel to and at a distance not exceeding three feet from the line when the line

and return are both erected overhead, or eighteen inches when they are both laid underground.

15. In the disposition, connections, and working of feeders, the Company shall take all reasonable precautions to avoid injurious interference with any existing wires.

16. The Company shall so construct and maintain their system as to secure good contact between the motors and the line and return respectively.

17. The Company shall adopt the best means available to prevent the occurrence of undue sparking at the rubbing or rolling contacts in any place and in the construction and use of their generator and motors.

18. Where the line or return or both are laid in a conduit the following conditions shall be complied with in the construction and maintenance of such conduit:

(*a.*) The conduit shall be so constructed as to admit of examination of and access to the conductors contained therein and their insulators and supports.

(*b.*) It shall be so constructed as to be readily cleared of accumulation of dust or other *debris*, and no such accumulation shall be permitted to remain.

(*c.*) It shall be laid to such falls and so connected to sumps or other means of drainage, as to automatically clear itself of water without danger of the water reaching the level of the conductors.

(*d.*) If the conduit is formed of metal, all separate lengths shall be so jointed as to secure efficient metallic continuity for the passage of electric currents. Where the rails are used to form any part of the return they shall be electrically connected to the conduit by means of copper strips having a sectional area of at least one-sixteenth of a square inch, or other means of equal conductivity, at distances apart not exceeding 100 feet. Where the return is wholly insulated and contained within the conduit, the latter shall be connected to earth at the generating station or sub-station through a high resistance galvanometer suitable for the indication of any contact or partial contact of either the line or the return with the conduit.

(*e*) If the conduit is formed of any non-metallic material not being of a high insulating quality and impervious to

moisture throughout, the conductors shall be carried on insulators the supports for which shall be in metallic contact with one another throughout.

(*f.*) The negative conductor shall be connected with earth at the station by a voltmeter and may also be connected with earth at the generating station or sub-station by an adjustable resistance and current indicator. Neither conductor shall otherwise be permanently connected with earth.

(*g.*) The conductors shall be constructed in sections not exceeding one-half a mile in length, and in the event of a leak occurring on either conductor that conductor shall at once be connected with the negative pole of the dynamo, and shall remain so connected until the leak can be removed.

(*h.*) The leakage current shall be ascertained daily, before or after the hours of running, when the line is fully charged, and if at any time it shall be found to exceed one ampere per mile of tramway the leak shall be localized and removed as soon as practicable, and the running of the cars shall be stopped unless the leak is localized and removed within 24 hours.

19. The Company shall, so far as may be applicable to their system of working, keep records as specified below. These records shall, if and when required, be forwarded for the information of the Board of Trade.

DAILY RECORDS.

No. of cars running.

No. of miles of single tramway line.

Maximum working current.

Maximum working pressure.

Maximum current from the earth plate or water-pipe connections (*vide* Regulation 6 (i.)).

Leakage current (*vide* Regulations 11 and 18 (*h.*)).

Fall of potential in return (*vide* Regulations 7).

MONTHLY RECORDS.

Condition of earth connections (*vide* Regulation 5).

Minimum insulation resistance of insulated cables in megohms per mile (*vide* Regulation 12).

QUARTERLY RECORDS.

Conductance of joints to pipes (*vide* Regulation 9).

OCCASIONAL RECORDS.

Specimens of tests made under provisions of Regulation 6 (ii).

BOARD OF TRADE,
7, Whitehall Gardens, S. W.

August, 1904.

GREAT BRITAIN—EXHIBIT C.

MODEL BILLS AND CLAUSES.

II.—TRAMWAY BILL.

1. The Companies Clauses Consolidation Act 1845, Part I. (relating to cancellation and surrender of shares) of the Companies Clauses Act 1863 as amended by subsequent Acts, the Lands Clauses Acts, and section 3 (Interpretation of terms) Part II. (Construction of tramways) and Part III. (General provisions) of the Tramways Act 1870, are (except where expressly varied by this Act) incorporated with and form part of this Act.

2. In this Act the several words and expressions to which meanings are assigned by the Acts wholly or partially incorporated herewith have the same respective meanings unless there be something in the subject of context repugnant to such constructions: And in this Act unless the context otherwise requires—

"The Company" means the Company incorporated by this Act;

"The tramways" and "the undertaking" mean respectively the tramways and other works and the undertaking by this Act authorized;

"Mechanical power" includes electrical and every other motive power not being steam or animal power;

"Engine" includes motor.

References to Clauses in other Model Bills are given verbatim, but these other Model Bills are not reproduced.

"Contingencies" in Section 122 of the Companies Clauses Consolidation Act 1845 include the contingency of the undertaking being sold to the local authority under Section 43 of the Tramways Act 1870 at a sum less than the aggregate amount of the capital and debts of the Company.

[And in this Act and for the purposes of this Act in the Tramways Act 1870 and the recited Acts the expression "local authority" shall mean in reference to a rural district the district council of that district.]

3. [*Incorporation clause; sec. p. 2.*]

POWER TO CONSTRUCT.

4. Subject to the provisions of this Act *and of Parts II and III of the Tramways Act* 1870 the Company may make form lay down work use and maintain the tramways hereinafter described in the lines and according to the levels and within the limits of deviation shown on the deposited plans and sections and in all respects in accordance with those plans and sections with all proper rails plates works and conveniences connected therewith: Provided that nothing in this Act shall authorize any interference with electric lines and works of any undertakers under the Electric Lighting Acts 1882 and 1888 to which the provisions of Section 15 of the former Act apply except in accordance with and subject to the provisions of that section.

The tramways hereinbefore referred to and authorized by this Act are—

A tramway (single line) in length commencing at and terminating at

5. The Company may erect, maintain and use, on the lands described in the *First* Schedule to this Act annexed, a station or stations for producing and generating, transforming, storing and applying electrical power with all such buildings, engines, batteries, dynamos, accumulators and other plant machinery, apparatus, works, and conveniences, as may be necessary or suitable for those purposes, and may produce, generate, transform, store, use, and apply such power accordingly.

The Standing Orders require that the length of each tramway shall be set forth in miles, furlongs, chains, and links or yards, or decimals of a chain; also a statement whether the tramway is a single or double line.

6. (I) The Company may, in, under or over the surface of the streets or roads in which the tramways by this Act authorized will be situate, or in which it may be necessary so to do in order to connect the tramways with any generating station, construct, lay down, erect, maintain, renew and repair electric wires, conductors, posts, tubes, boxes and other electrical apparatus, and may make and maintain openings and ways for the purpose of working the tramways by electrical power, and may for that purpose subject to the provisions contained in Part II. of the Tramways Act 1870 and to the provisions of this Act open and break up any such street or road and any sewers, drains, water or gas pipes, tubes, wires, telephonic and telegraphic apparatus therein or thereunder: Provided as follows:

(*a*) All posts and apparatus erected by the Company under the powers of this Act in any street or road shall be of such design as the local authority may approve, and shall be placed in such position as the local authority and road authority may approve: Provided that no post or other apparatus shall be erected on the carriageway except with the consent of the Board of Trade;

(*b*) The route in which any electrical apparatus is to be laid or erected for the purpose of connecting the tramways with a generating station shall be approved by the local authority and the road authority, within whose jurisdiction each portion of the route is situate.

(2) Nothing in this section shall extend to or authorize any interference with any works of any undertakers within the meaning of the Electric Lighting Acts 1882 and 1888 to which the provisions of Section 15 of the former Act apply.

7. When by reason of the execution of any work affecting the surface or soil of any road along or across the carriageway of which any of the tramways are or is laid, it shall in the opinion of the road authority be expedient temporarily to remove or discontinue the use of such tramway or any part thereof, the Company may, with the consent of the road authority and subject to such conditions as the road authority may impose, construct in the same or any adjacent road and

(so long as occasion may require) maintain a temporary tramway in lieu of the tramway or part of the tramway so removed or discontinued.

If any difference arises between the Company and the road authority with respect to any conditions or with respect to the mode of constructing any temporary tramway under the authority of this section, the same shall be settled by arbitration under this Act.

8. The Company may increase the roadway of any street in which any of the tramways are authorized to be laid to such extent as may be necessary to leave a space of nine feet and six inches between the outside of the footpath on each or either side of such street and the nearest rail of the tramway by reducing the width of the footpath on each or either side of such street: Provided that any footpath shall not be reduced in width without the consent of the local authority and the road authority or other person in whom it is vested nor to such an extent as to be less than six feet wide.

9. The Company may erect and maintain shelters or waiting-rooms for the accommodation of passengers, and may, with the consent of the local authority and road authority, use for that purpose portions of the public streets or roads.

Mode of Construction, Restrictions, etc.

10. (1) The tramways shall be constructed on a gauge of *four feet eight and a half inches* or such other gauge as may from time to time be approved by the Board of Trade but carriages or trucks adapted to run on railways shall not be run thereon.

(2) In the event of the tramways being constructed on a less gauge than *four feet eight and a half inches* so much of Section 74 of the Tramways Act 1870 as limits the extent of the carriage used on any tramway beyond the edge of the wheels of such carriage shall not apply to carriages used on the tramways but no carriage or engine shall exceed *six feet three inches* in width or such other width as may from time to time be prescribed by the Board of Trade.

11. The rails of the tramways shall be such as the Board of Trade may approve.

12. In addition to the requirements of Section 26 of the Tramways Act 1870 the Company shall lay before the Board of Trade and the road authority a plan showing the proposed mode of constructing, laying down and renewing such tramways, and a statement of the materials intended to be used therein, and the company shall not commence the construction, laying down and renewal of any of the tramways or part of any of the tramways respectively until such plan and statement have been approved by the Board of Trade, and after such approval the works shall be executed in accordance in all respects with such plan and statement and under the superintendence and to the reasonable satisfaction of the surveyor of the road authority as provided by Section 26 of the said Act.

13. (1) The Company shall at all times maintain and keep in good condition and repair and so as not to be a danger or annoyance to the ordinary traffic the rails of the tramways *by this Act authorized and of all other tramways of the Company* and the sub-structure upon which the same rest, and if the Company at any time fail to comply with this provision or with the provisions of Section 28 of the Tramways Act 1870, they shall be liable to a penalty not exceeding five pounds and to a daily penalty not exceeding five pounds. *The tramways of the Company for the purposes of this section include any tramways purchased by the Company or taken on lease by them during the continuance of any such lease.*

(2.) In case it is represented in writing to the Board of Trade by the road authority of any district in which the tramways or any portion thereof are or is situate or by twenty inhabitant ratepayers of such district that the *Company* have made default in complying with the provisions in this section contained or with any of the requirements of Section 28 of the Tramways Act 1870, the Board of Trade may if they think fit direct an inspection by an officer to be appointed by the said Board, and if the officer reports that the default mentioned in such representation has been proved to his satisfaction, then and in every such case a copy of such report certified by a secretary or an assistant secretary of the Board of Trade may be adduced as evidence of such default and of the liability

of the *Company* to such penalty or penalties in respect thereof as is or are by this section imposed.

14. If and whenever after the passing of this Act any road authority alters the level of any road along or across which any part of the tramway is laid or authorized to be laid. the *Company* may and shall from time to time alter or (as the case may be) lay their rails so that the uppermost surface thereof shall be on a level with the surface of the road as altered.

15. Any paving metalling or material excavated by the *Company* in the construction of the tramways from any road under the jurisdiction or control of any road authority may be applied by the *Company* so far as may be necessary in or towards the reinstatement of the road and the maintenance for six months after completion of any of the tramways within the district of such road authority of so much of the roadway on either side of such tramways as the *Company* are by Section 28 of the Tramways Act 1870 required to maintain; and the *Company* shall, if so required, deliver the surplus paving metalling or material not used or required to be retained for the purposes aforesaid to the surveyor of the road authority or to such person or persons as he may appoint to receive the same: Provided that if within seven days after the setting aside of the surplus arising from the excavation of any such paving metalling or material, and notice duly given such surplus is not removed by such surveyor or by some other person named by him for that purpose, such surplus paving metalling or material shall absolutely vest in and belong to the *Company*, and may be dealt with, removed and disposed of by them in such manner as they may think fit. Any difference between the *Company* and any road authority, or surveyor, or other person with reference to any of the matters aforesaid shall be settled by an arbitrator to be nominated by the Board of Trade on the application of either party.

16. Every sanitary authority shall at all times have free access to and communication with all their sewers and drains, and power to lay lateral and private drains to communicate therewith without the consent or concurrence of the *Company*, and the provisions contained in Sections 32 and 33 of the Tramways Act 1870 shall be applicable in the case of any

sewer or private drain of or under the control of the said authority as if the same were a pipe for the supply of gas or water.

17. Where in any road in which a double line of tramway is laid there shall be less width between the outside of the footpath on either side of the road and the nearest rail of the tramway than nine feet six inches, the *Company* shall if and where required by the Board of Trade construct a cross-over or cross-overs connecting the one tramway with the other, and by the means of such cross-over or cross-overs the traffic shall when necessary be diverted from one tramway to the other.

18. The *Company* may subject to the provisions of this Act with the consent of the Board of Trade, make, maintain, alter and remove such cross-overs, passing places, sidings, junctions and other works in addition to those particularly specified in and authorized by this Act as they find necessary or convenient for the efficient working of the tramways or for providing access to any warehouses, stables or carriage houses or works of the *Company*.

(2) Notwithstanding anything shown on the deposited plans, the *Company* may, with the consent of the Board of Trade, lay down double lines in lieu of single or interlacing lines or single lines in lieu of double or interlacing lines or interlacing lines in lieu of double or single lines on any of the tramways, and may with the like consent at any time alter the position in the road of any of the tramways or any part thereof.

(3) Provided that if in the construction of any works under this section any rail is intended to be laid nearer to the footpath than previously authorized in such a manner that, for a distance of thirty feet or upwards, a less space than nine feet six inches would intervene between it and the outside of the footpath on either side of the road, the *Company* shall not less than one month before commencing the works give notice in writing to every owner and occupier of houses, shops or warehouses abutting on the place where such less space would intervene, and such rail shall not be so laid if the owners or occupiers of one-third of such houses, shops or warehouses by writing under their hands addressed and delivered to the

Company within three weeks after receiving the notice from the *Company* express their objection thereto.

USE OF MECHANICAL POWER.

19. The carriages used on the tramways may be moved by animal power or subject to the following provisions by mechanical power (that is to say):

(1) The mechanical power shall not be used except with the consent of and according to a system approved by the Board of Trade:

(2) The Board of Trade shall make regulations (in this Act referred to as "the Board of Trade regulations") for securing to the public all reasonable protection against danger arising from the use under this Act of mechanical power on the tramways and for regulating the use of electrical power:

(3) The *Company* (1) or any [other] company or persons using any mechanical power on the tramways contrary to the provisions of this Act or of the Board of Trade regulations shall for every such offense be liable to a penalty not exceeding ten pounds and also in the case of a continuing offense to a further penalty not exceeding five pounds for every day during which such offense is continued after conviction thereof:

(4) The Board of Trade if they are of opinion—

(A) That the *Company* or such [other] company or person have or has made default in complying with the provisions of this Act or of the Board of Trade regulations whether a penalty in respect of such non-compliance has or has not been recovered; or—

(B) That the use of mechanical power as authorized under this Act is a danger to the passengers or the public; may by order either direct the *Company* or such [other] company or person to cease to use such mechanical power or permit the same to be continued only subject to such conditions as the Board of Trade may impose, and the *Company* or such [other] company or person shall comply with every such order. In every such case the

(1) Or Corporation, District Council, or as the case may be.

Board of Trade shall make a special report to Parliament notifying the making of such order.

20. The following provisions shall apply to the use of electrical power under this Act unless such power is entirely contained in and carried along with the carriages:

(1) The *Company* shall employ either insulated returns or uninsulated metallic returns of low resistance:

(2) The *Company* shall take all reasonable precautions in constructing, placing and maintaining their electric lines and circuits and other works of all descriptions, and also in working the undertaking, so as not injuriously to effect by fusion or electrolytic action any gas or water pipes or other metallic pipes, structures or substances or to interfere with the working of any wire line or apparatus from time to time used for the purpose of transmitting electrical power or of telegraphic, telephonic or electric signaling communicating or the currents in such wire line or apparatus:

(3) The electrical power shall be used only in accordance with the Board of Trade regulations and in such regulations provision shall be made for preventing fusion or injurious electrolytic action of or on gas or water pipes, or other metallic pipes, structures or substances, and for minimizing as as far as is reasonably practicable injurious interference with the electric wires, lines and apparatus of other parties and the currents therein, whether such lines do or do not use the earth as a return:

(4) The *Company* shall be deemed to take all reasonable precautions against interference with the working of any wires, line or apparatus, if and so long as they adopt and employ at the option of the *Company* either such insulated returns or such uninsulated metallic returns of low resistance and such other means of preventing injurious interference with the electric wires, lines and apparatus of other parties and the currents therein, as may be prescribed by the Board of Trade regulations, and in prescribing such means the Board shall have regard to the expense involved and to the effect thereof upon the commercial prospects of the undertaking.

(5) At the expiration of two years from the passing of this Act the provisions of this section shall not operate to give

any right of action in respect of injurious interference with any electric wire, line or apparatus, or the currents therein, unless in the construction, erection, maintaining and working of such wire, line and apparatus, all reasonable precautions including the use of an insulated return have been taken to prevent injurious interference therewith and with the currents therein by or from other electric currents:

(6) If any difference arises between the *Company* and any other party with respect to anything hereinbefore in this section contained, such difference shall, unless the parties otherwise agree, be determined by [arbitration] the Board of Trade or at the option of the Board by an arbitrator to be appointed by the Board, and the costs of such determination shall be in the discretion of the Board or of the arbitrator as the case may be:

(7) *When any Department of His Majesty's Government represents to the Board of Trade that the use of electrical power under this Act injuriously affects or is likely to injuriously affect any instruments or apparatus, whether electrical or not, used in any observatory or laboratory belonging to or under the control of that department, the Board of Trade after such inspection or inquiry as they may think proper may by their regulations require the Company to use such reasonable and proper precautions including insulated returns as the Board of Trade may deem necessary for the prevention of such injurious affection. For the purposes of this subsection any inspector of the Board of Trade may during his inspection of the Company's works and apparatus be accompanied by any person or persons appointed in that behalf by the Government Department concerned, and the Company shall give all due facilities for the inspection. Provided always that in the case of any observatory or laboratory established after the passing of this Act, or of any instruments or apparatus hereafter used in any existing observatory or laboratory which may be of greater delicacy than those used therein at the passing of this Act, the Board of Trade shall consider to what extent, if any, it is expedient in the interests of the public that the power of this subsection should be exercised, regard being had to the site of the observatory or laboratory or the purposes of the instruments or apparatus as the case may be.*

(8) The expression "*Company*" in this section shall include [lessees (1)] licensees and any person owning, working or running carriages over any tramway of the *Company*.

21. Notwithstanding anything in this Act contained, if any of the works authorized to be executed by this Act involves or is likely to involve any alteration of any telegraphic line belonging to or used by the Postmaster-General, the provisions of Section 7 of the Telegraph Act 1878 shall apply (instead of the provisions of Section 30 of the Tramways Act 1870) to any such alteration.

22 (2) In the event of any tramways of the *Company* being worked by electricity the following provisions shall have effect :

(1) The *Company* shall construct their electric lines and other works of all descriptions, and shall work their undertaking in all respects with due regard to the telegraphic lines from time to time used or intended to be used by His Majesty's Postmaster-General and the currents in such telegraphic lines, and shall use every reasonable means in the construction of their electric lines and other works of all descriptions, and the working of their undertaking to prevent injurious affection whether by induction or otherwise to such telegraphic lines or the currents therein. Any difference which arises between the Postmaster-General and the *Company* as to compliance with this sub-section shall be determined by arbitration :

(2) If any telegraphic line of the Postmaster-General is injuriously affected by the construction by the *Company* of their electric lines and works, or by the working of the undertaking of the *Company*, the *Company* shall pay the expense of all such alterations in the telegraphic lines of the Postmaster-General as may be necessary to remedy such injurious affection :

(3) Before any electric line is laid down or any act or work for working the tramways by electricity is done within ten yards of any part of a telegraphic line of the Postmaster-General (other than repairs), the *Company* or their agents, not more than twenty-eight nor less than fourteen days, before

(1) Where the promoters are a local authority.

(2) This clause is proper to be used also in the case of above-ground railways worked by electricity.

commencing the work, shall give written notice to the Postmaster-General specifying the course of the line and the nature of the work, including the gauge of any wire, and the *Company* and their agents shall conform with such reasonable requirements (either general or special) as may from time to time be made by the Postmaster-General for the purpose of preventing any telegraphic line of the Postmaster-General from being injuriously affected by the said act or work. Any difference which arises between the Postmaster-General and the *Company* as to any requirement so made shall be determined by arbitration:

(4) If any telegraphic line of the Postmaster-General situate within one mile of any portion of the works of the *Company* is injuriously affected and he is of opinion that such injurious affection is or may be due to the construction of the Company's works or to the working of the undertaking, the engineer-in-chief of the Postoffice, or any person appointed in writing by him, may at all times when electrical energy is being generated by the *Company* enter any of the Company's works for the purpose of inspecting the Company's plant and the working of the same, and the *Company* shall in the presence of such engineer-in-chief or such appointed person as aforesaid make any electrical tests required by the Postmaster-General, and shall produce for the inspection of the Postmaster-General the records kept by the *Company* pursuant to the Board of Trade regulations: (1)

(5) In the event of any contravention of or wilful non-compliance with this section by the *Company* or their agents, the *Company* shall be liable to a fine not exceeding ten pounds for every day during which such contravention or non-compliance continues, or if the telegraphic communication is wilfully interrupted not exceeding fifty pounds for every day on which such interruption continues:

(6) Provided that nothing in this section shall subject the *Company* or their agents to a fine under this section if they satisfy the court having cognizance of the case that the

(1) Where this clause is applied to a company having a separate electrical undertaking, this sub-section may be confined to the works "by this Act authorized" and to the generation of electrical energy "for the purposes of this Act."

immediate doing of any act or the execution of any work in respect of which the penalty is claimed was required to avoid an accident or otherwise was a work of emergency, and that they forthwith served on the postmaster or sub-postmaster of the postal telegraph office nearest to the place where the act or work was done, a notice of the execution thereof, stating the reason for doing or executing the same without previous notice:

(7) For the purposes of this section a telegraphic line for the Postmaster-General shall be deemed to be injuriously affected by an act or work if telegraphic communication by means of such line is whether through induction or otherwise in any manner affected by such act or work or by any use made of such work:

(8) For the purposes of this section and subject as therein provided, Sections 2, 10, 11 and 12 of the Telegraph Act 1878 shall be deemed to be incorporated with this Act:

(9) The expression "electric line" has the same meaning in this section as in the Electric Lighting Act 1882:

[(10) Any question or difference arising under this section which is directed to be determined by arbitration shall be determined by an arbitrator appointed by the Board of Trade on the application of either party whose decision shall be final, and Sections 30 to 32 both inclusive of the Regulation of Railways Act 1868 shall apply in like manner as if the *Company* or their agents were a company within the meaning of that Act:]

(11) Nothing in this section contained shall be held to deprive the Postmaster-General of any existing right to proceed against the *Company* by indictment, action or otherwise in relation to any of the matters aforesaid:

(12) In this section the expression "the *Company*" includes their lessees and any person owning, working or running carriages on any of the tramways of the *Company*.

23. The provisions of Sections 26 to 33 [*and 41] of the Tramways Act 1870 (except so much of Section 28 as relates to the repair of the road between and on each side of the rails of a tramway) shall apply as if all posts, tubes, pipes, wires

* Reference to section 41 should be omitted in local authorities' Bills.

and other apparatus, used, or to be used by the *Company* for the purposes of mechanical power were parts of the tramway.

24. The *Company* may, with the consent of the owner of any building, attach to that building such brackets, wires and apparatus, as may be required for the working of the tramways by mechanical power:

Provided that—

(1) Where in the opinion of the *Company* any consent under this section is unreasonably refused, they may appeal to a petty sessional court, who shall have power, having regard to the character of the building and to the other circumstances of the case, to allow the attachment subject to such terms as to compensation or rent, and otherwise as they may think reasonable, or to disallow the same, and may determine by which of the parties the costs of the appeal are to be paid:

(2) Any consent of an owner and any order of a petty sessional court under this section shall not have effect after that owner ceases to be in possession of the building, but any attachments fixed under the provisions of this section shall not be removed until the expiration of three months after any subsequent owner shall have given to the *Company* notice in writing requiring the attachments to be removed. Where such notice is given the preceding provisions of this section shall apply and the petty sessional court shall have the same powers as under proviso (1):

(3) The owner may require the *Company* to temporarily remove the attachments where necessary during any reconstruction or repair of the building.

For the purpose of this section any occupier of a building whose tenancy exceeds one year unexpired and in the case of any other tenancy the person receiving the rackrent shall be deemed to be the owner.

25. Subject to the provisions of this Act the Board of Trade may make bylaws with regard to any of the tramways upon which mechanical power may be used for all or any of the following purposes (that is to say):

For regulating the use of any bell, whistle or other warning apparatus fixed to the engine or carriages :

For regulating the emission of smoke or steam from engines used on the tramways :

For providing that engines and carriages shall be brought to a stand at the intersection of cross streets, and at such places and in such cases of horses being frightened, or of impending danger, as the Board of Trade may deem proper for securing safety :

For regulating the entrance to, exit from and accommodation in the carriages used on the tramways and the protection of passengers from the machinery of any engine used for drawing or propelling such carriages :

For providing for the due publicity of all bylaws and Board of Trade regulations in force for the time being in relation to the tramways by exhibition of the same in conspicuous places on the carriages and elsewhere :

Any person offending against or committing a breach of any of the by-laws, made by the Board of Trade under the authority of this Act, shall be liable to a penalty not exceeding forty shillings.

WORKING BY LOCAL AUTHORITY.

26. Notwithstanding anything in the Tramways Act 1870 to the contrary the *Corporation* (1) may place and run carriages on and may work and may demand and take tolls and charges in respect of any tramways within the *borough* now belonging to the *Corporation* or authorized in or prior to the present Session of Parliament to be constructed by them, and in respect of the use of such carriages, and may provide such stables, buildings, carriages, trucks, harness, engines, machinery, apparatus, horses, steam, cable, electric and other plant appliances and conveniences as may be requisite or expedient for the convenient working, or user, of the said tramways by animal or mechanical power, but nothing in this section shall empower the *Corporation* to create or permit a nuisance.

27. The regulations authorized by the Tramways Act 1870 to be made by the promoters of any tramway and their lessees

(1) Or as the case may be.

may with respect to any tramways or portions of tramways for the time being belonging to and worked by the *Corporation* be made by the *Corporation* alone.

COMPLETION.

28. The tramway shall not be opened for public traffic until it has been inspected and certified to be fit for such traffic by the Board of Trade.

29. The tramway shall be completed within *five* years from the passing of this Act, and on the expiration of that period the powers, by this Act granted to the Company for executing the same or otherwise in relation thereto, shall cease except as to so much thereof as shall then be completed.

DEPOSIT OR PENALTY.

30. Whereas, pursuant to the Standing Orders of both Houses of Parliament and to the Parliamentary Deposits Act 1846 a sum of —— [stock Exchequer bills] being five per cent. upon the amount of the estimate in respect of the tramway has been deposited with [transferred into the name of] the Paymaster General for and on behalf of the Supreme Court [Accountant General of the Supreme Court *in Ireland*] in respect of the application to Parliament for this Act (which sum [stock Exchequer bills] is [are] referred to in this Act as the deposit fund) : Be it enacted that notwithstanding anything contained in the said Act the said deposit fund shall not be paid or transferred to or on the application of the person or persons or the majority of the persons named in the warrant or order issued in pursuance of the said Act or the survivors or survivor of them (which person, survivors or survivor, are, or is in this Act referred to as the depositors), unless the Company shall, previously to the expiration of the period limited by this Act for completion of the tramway, open the same for the public conveyance of passengers, and if the company shall make default in so opening the tramway, the deposit fund shall be applicable, and shall be applied as provided by the next following section : Provided that if within such period as aforesaid the Company opens any portion of the

tramway for the public conveyance of passengers, then on the production of a certificate of the Board of Trade specifying the length of the portion of the tramway opened as aforesaid, and the portion of the deposit fund, which bears to the whole of the deposit fund the same proportion as the length of the tramway so opened bears to the entire length of the tramway hereby authorized, the High Court shall, on the application of the depositors order the portion of the deposit fund specified in the certificate to be paid or transferred to them or as they shall direct, and the certificate of the Board of Trade shall be sufficient evidence of the facts therein certified, and it shall not be necessary to produce any certificate of this Act having passed anything in the above mentioned Act to the contrary notwithstanding.

31. If the Company do not, previously to the expiration of the period limited for the completion of the tramway, complete the same and open it for the public conveyance of passengers, then, and in every such case the deposit fund, or so much thereof as shall not have been paid to the depositors, shall be applicable, and after due notice in the *London* Gazette shall be applied towards compensating any landowners or other persons whose property has been interfered with or otherwise rendered less valuable by the commencement, construction or abandonment of the tramway, or any portion thereof; *or who have been subjected to injury or loss in consequence of the compulsory powers of taking property conferred upon the Company by this Acts*, and also in compensating all road authorities for the expense incurred by them in taking up any tramway or materials connected therewith placed by the Company in or on any road vested in or maintainable by such road authorities respectively, and in making good all damage caused to such roads by the construction or abandonment of such tramway, and shall be distributed in satisfaction of such compensation as aforesaid in such manner and in such proportions as to the High Court may seem fit; and if no such compensation is payable or if a portion of the deposit fund has been found sufficient to satisfy all just claims in respect of such compensation, then the deposit fund or such portion thereof as may not be required as aforesaid shall, if a receiver has been

appointed or the Company is insolvent and has been ordered to be wound up or the undertaking has been abandoned, be paid or transferred to such receiver or to the liquidator or liquidators of the Company or be applied in the discretion of the court as part of the assets of the Company for the benefit of the creditors thereof, and subject to such application shall be repaid or retransferred to the depositors: Provided that until the deposit fund has been repaid [retransferred] to the depositors, or has become otherwise applicable as hereinbefore mentioned, any interest or dividends accruing thereon shall, as and when the same become payable be paid to or on application of the depositors.

[The two following clauses are to be substituted in every Bill whereby the construction of any new line of tramway is authorized, or the time for completing any line already authorized is extended, promoted by any existing tramway company which is possessed of a tramway already opened for public traffic, and which has during the year last past paid dividends on its ordinary share capital, and which does not propose to raise under the Bill a capital greater than its existing authorized capital.]

30A. If the company fail within the period limited by this Act to complete the tramway and open the same for public traffic, the Company shall be liable to a penalty of fifty pounds a day for every day after the expiration of the period so limited until the tramway is completed and opened for public traffic, or until the sum received in respect of such penalty amounts to five per cent. on the estimated cost of the works, and the said penalty may be applied for by any road authority, landowner or other person claiming to be compensated or interested in accordance with the provisions of the next following section of this Act and in the same manner as the penalty provided in Section 3 of the Railway and Canal Traffic Act 1854; and every sum of money recovered by way of such penalty as aforesaid shall be paid under the warrant or order of such court or judge as is specified in that section to an account opened or to be opened in the name of the Paymaster-General, for, and on behalf of the Supreme Court [the Accountant General of the Supreme Court in Ireland] in the bank [and to the credit] specified in such warrant or order, and shall not be paid thereout except as hereinafter provided, but no penalty shall accrue in respect of any time during which it

shall appear by a certificate to be obtained from the Board of Trade that the Company was prevented from completing or opening such line by unforeseen accident or circumstances beyond their control, provided that the want of sufficient funds shall not be held to be a circumstance beyond their control.

31A. Every sum of money so recovered by way of penalty as aforesaid shall be applicable and after due notice in the *London* Gazette shall be applied towards compensating any landowners or other persons whose property may have been interfered with or otherwise rendered less valuable by the commencement construction or abandonment of the tramway or any portion thereof, *or who may have been subjected to injury or loss in consequence of the compulsory powers of taking property conferred upon the Company by this Act*, and also in compensating all road authorities for the expense incurred by them in taking up any tramway or material connected therewith placed by the Company in or on any road vested in or maintainable by such road authorities respectively and in making good all damage caused to such roads by the construction or abandonment of such tramway, and shall be distributed in satisfaction of such compensation as aforesaid in such manner and in such proportions as to the High Court may seem fit; and if no such compensation shall be payable or if a portion of the sum or sums of money so recovered by way of penalty as aforesaid shall have been found sufficient to satisfy all just claims in respect of such compensation, then the said sum or sums of money recovered by way of penalty or such portion thereof as may not be required as aforesaid shall if a receiver has been appointed or the Company is insolvent and has been ordered to be wound up or the *undertaking* [tramway or tramways in respect of which the penalty has been incurred or any part thereof] has been abandoned be paid or transferred to such receiver or to the liquidator or liquidators of the Company or be applied in the discretion of the court as part of the assets of the Company for the benefit of the creditors thereof, and subject to such application shall be repaid or retransferred to the Company.

FARES, RATES AND CHARGES.

32. The *Company* may demand and take for every passenger traveling upon the tramway or any part or parts thereof including every expense incidental to such conveyance, a fare not exceeding one penny per mile ; and in computing the said fare the fraction of a mile shall be deemed a mile, but in no case shall the *Company* be bound to charge a less sum than *one penny*.

33. Every passenger traveling upon the tramway may take with him his personal luggage not exceeding twenty-eight pounds in weight, without any charge being made for the carriage thereof, all such luggage to be carried by hand and not to occupy any part of a seat, nor to be of a form or description to annoy or inconvenience other passengers.

34. The *Company* shall not be bound, unless they think fit, to carry passengers' luggage exceeding   pounds in weight, nor any parcel of goods. (1)

35. Goods, animals, articles or things (other than passengers and passengers' luggage and parcels not exceeding fifty-six pounds in weight) shall not be conveyed on the tramway between the hours of eight in the morning and eight in the evening, without the consent of the local authority and the road authority.

If the Company is not to be authorized to take rates and charges for animals and goods, the following clause is to be inserted :

36. The *Company* shall not carry on the tramways any goods, animals or other things other than passengers and passengers' luggage, not exceeding the weight in this Act in that behalf mentioned and small parcels.

37. The *Company* shall not take or demand on Sunday, or any public holiday, any higher fares or charges than those levied by them on ordinary week days.

38. (1) The *Company* at all times after the opening of the tramways for public traffic, shall, and they are hereby required to run a proper and sufficient service of carriages for artisans, mechanics and daily laborers each way every morning

(1) Where animals and goods are intended to be carried a clause should be inserted fixing the maximum rates for such carriage (*see*, for instance, Nottinghamshire, etc., Act, 1903, c. 164, s. 38).

and every evening (Sundays, Christmas Day and Good Friday always excepted); at such hours not being later than eight in the morning or earlier than five in the evening, respectively, as may be most convenient for such workmen going to and returning from their work, at fares not exceeding one-half penny for every *mile* or fraction of that distance. On Saturdays the *Company*, in lieu of running such carriages after five o'clock in the evening, shall run the same at such hours between *noon* and *two o'clock* in the afternoon, as may be most convenient for the said purpose.

(2) If complaint is made to the Board of Trade that such proper and sufficient service is not provided, the Board, after considering the circumstances of the locality, may, by order, direct the *Company* to provide such service as may appear to the Board to be reasonable.

(3) The *Company* shall be liable to a penalty not exceeding five pounds for every day during which they fail to comply with any order under this section.

39. If at any time after three years from the opening for public traffic of the tramways or any portion thereof or after three years from the date of any order made in pursuance of this section, in respect of the tramways or any portion thereof, it is represented in writing to the Board of Trade by the local authority of any district in which the tramways or such portion are, or is wholly or partly situate, or by twenty inhabitant ratepayers of that district, or by the *Company*, that under the circumstances then existing, all or any of the fares or other charges demanded, and taken in respect of the traffic on the tramways, or on such portion, should be revised, the Board of Trade may (if they think fit) direct an inquiry by a referee to be appointed by the said Board, in accordance with the provisions of the Tramways Act 1870; and if the referee reports that it has been proved, to his satisfaction, that all or any of the fares or charges should be revised, the said Board may, subject to the maximum fares and charges authorized by this Act, by order in writing, alter, modify, reduce or increase all or any of the fares or charges to be taken in respect of the tramways or on any portion thereof; and thenceforth such order shall be observed until the same is revoked or modified

by an order of the Board of Trade, made in pursuance of this section : *Provided that a copy of this section shall be annexed to every table or list of fares published or exhibited by the Company.*

LANDS.

40. Subject to the provisions of this Act, the Company may enter upon, take hold and use for the purposes of their undertaking, the following lands shown on the deposited plans and described in the deposited book of reference (that is to say) &c.

41. The powers of the Company for the compulsory purchase of lands for the purposes of this Act shall cease, after the expiration of three years from the passing of this Act.

42. If there be any omission, mis-statement or wrong description of any lands or of the owners, lessees or occupiers of any lands shown on the deposited plan, or specified in the deposited book of reference, the Company after giving ten days' notice to the owners, lessees and occupiers of the land in question, may apply to two justices acting for the county of   for the correction thereof; and if it appear to the justices that the omission, mis-statement or wrong description arose from mistake, they shall certify the same accordingly, and they shall, in their certificate, state the particulars of the omission; and in what respect any such matter is mis-stated or wrongly described, and such certificate shall be deposited with the clerk of the peace for the county of   and a duplicate thereof shall also be deposited with the clerks of the *parish councils* [*or as the case may be*] in which the lands affected thereby are situate, and such certificate and duplicate, respectively, shall be kept by such clerk of the peace and clerks of parish councils respectively with the other documents to which the same relate; and thereupon the deposited plan and book of reference shall be deemed to be corrected according to such certificate, and it shall be lawful for the *Company* to take the lands and execute the works in accordance with such certificate.

43. In addition to the other lands, which the Company are by this Act authorized to purchase and acquire, they may purchase, take on lease or acquire by agreement and may hold

for the purpose of their undertaking any lands not exceeding *ten* acres, and they may on such lands erect or construct and hold depots, yards, wharves, offices, buildings, sidings, works and other conveniences in connection with their undertaking; but nothing in this Act shall exonerate the Company from any indictment, action or other proceeding for nuisance in the event of any nuisance being caused or permitted by them on any such lands.

CAPITAL, ETC.

[Here insert clauses for Capital, etc.: see p. 2 et seq.; but the following clauses are necessary in Tramway Bills.]

44. The Company shall not create debenture stock.

45. Every mortgage of the Company's undertaking shall be deemed to comprise all purchase money, which may be paid to the Company, in the event of a compulsory sale to the local authority under Section 43 of the Tramways Act 1870, and may comprise all or any moneys carried to the contingency fund, according to the terms of the mortgage; and every mortgage deed shall be endorsed with notice that the mortgage will not be a charge upon the tramways or the tramway undertaking in the event of such sale.

MISCELLANEOUS.

46. The provisions of the Tramways Act 1870 relating to the making of by-laws by the local authority with respect to the rate of speed to be observed in traveling on the tramways, shall not authorize the local authority to make any by-laws sanctioning a higher rate of speed than that authorized by this Act, *or by the Board of Trade regulations*, but the by-laws of the local authority may restrict the rate of speed to a lower rate than that so authorized.

47. If any person willfully does, or causes to be done, with respect to any apparatus used for, or in connection with the working of any tramway of the *Company* anything which is calculated to obstruct or interfere with the working of such tramway, or to cause injury to any person, he shall (without prejudice to any proceedings by way of indictment or otherwise, to which he may be subject) be guilty of an offense punishable

on summary conviction, and every person convicted of such offense or of any offense under Section 50 of the Tramways Act 1870, with respect to any tramway of the *Company*, shall be liable to a penalty not exceeding twenty pounds.

48. Where the consent or approval of any local or road authority is by this Act required before the exercise of any powers by the Company, such consent or approval shall not be unreasonably withheld, and if any difference arises as to whether any consent or approval is unreasonably withheld, that difference shall be referred to arbitration.

49. (1) Where under this Act any question or dispute is to be referred to arbitration, then, unless other provision is made, the reference shall be to an arbitrator appointed by the Board of Trade, and the provisions of the Arbitration Act 1889 shall apply thereto.

50. All orders, regulations and by-laws made by the Board of Trade under the authority of this Act, shall be signed by a Secretary or an Assistant Secretary of the Board.

51. Any penalty under this Act or under any by-laws or regulations made under this Act may be recovered in manner provided by the Summary Jurisdiction Acts.

[In the case of Companies' Bills, here insert clauses "Interest on calls not to be paid out of capital" and "Deposits for future Bills not to be paid out of capital," see pp. 20, 21.]

52. Nothing in this Act contained shall exempt the *Company* or the tramway from the provisions of any general Act relating to tramways, passed before, or after the commencement of this Act, or from any future revision or alteration under the authority of Parliament of the maximum fares, rates or charges authorized by this Act.

Section IV.

Electrolysis in Germany.

The Deutscher Verein von Gas-und Wasserfachmännern have most kindly authorized your Committee to translate and utilize the admirable Reports of the German Electrolysis Commission. This favor not only relieves your Committee of

(1) See also general arbitration clause at p. 99.

the burden of any direct investigation of German conditions, but, moreover, provides a far more comprehensive and authoritative statement of the German status of the Electrolysis problem than could otherwise be obtained.

The following translations have been condensed, where possible, in order to encourage the study of this Section; and especial attention is directed to the "Regulations" which are given in full on pages 893 to 899.

Report of the Electrolysis Commission

of the German Society of Gas and Water Engineers in 1904.

[*Condensed Translation.*]

The Electrolysis Commission has continued its work in accordance with the following program, outlined at the Forty-third Annual Meeting at Zurich:

First, by issuing a Set of Questions, to collect a record of the conditions prevailing, and of the electrolytic experiences of Gas and Water Works, in various municipalities.

Secondly, by means of Special Investigations, to obtain the actual facts in regard to the relation between the earth currents and the destruction of pipes, as well as definite information regarding protective measures.

The Set of Questions was issued to 152 managements by means of a circular letter sent out by the general secretary of the Society, Geh. Hofrat Prof. Dr. Bunte. These questions are given on page 892.

130 replies were received, relating to 113 towns. [These replies have been tabulated by Prof. Dr. Teichmüller and may be seen, together with his report thereon, in the 1904 Proceedings of the Deutscher Verein von Gas-und Wasserfachmännern.]

Of these 113 towns 4 had at the time no electric tramway service, and the following discussion is, therefore, confined to 109 towns having electric roads.

As a result of the answers to question 2, these towns are arranged according to the kind of return circuits employed, as follows :

(a) 61 towns, or 56.0 per cent., have rail return circuits without return cables.

(b) 41 towns, or 37.5 per cent., have rail return circuits with insulated return cables.

(c) 7 towns, or 6.5 per cent., have rail return circuits with uninsulated return cables.

In many of these installations the return cable is simply a connection between the negative bus-bar and the point in the rail network nearest the central station, so that the return circuit is formed essentially by the rails themselves. This restriction of the return circuit to the rails is usually found only in the electric roads of small towns. In the electric roads of the larger towns, the rails, in nearly every case, are fitted with auxiliary cables for the return circuit.

As far as can be ascertained from the replies, the size of the return wires ranges from one-half to the full section of the outgoing cable.

Only 14 of the towns, or 13 per cent. out of a total of 109, replied in the affirmative to question 5; that is, that electrolytic destruction has been found in the gas and water pipes. The others replied in the negative. Of these 14 towns there were :

in two cases no return wires,

in one case uninsulated return wires,

in one case uninsulated and insulated return wires,

in ten cases insulated return wires.

In three of these towns (Hannover, Koenigsberg in Pr., and Strasburg in Els.) either the gas works or the water works reported corrosion, while the other reported that there was no corrosion. It must further be noted that in a number of towns, which replied in the negative to this question, corrosion was actually found on digging up the pipes. In consequence of this, and in view of the experience gathered and of the replies concerning the conditions of the return lines, it must be assumed that in the case of a large number of towns replying in the negative, corrosion was actually occurring, but was not so far advanced that damage to the pipes, producing leakage or escape of water or the like, had been noticed.

The replies to question 2 show how imperfect are the return

line arrangements in many cases, even occasionally in the larger cities.

In answer to question 7, a number of places report that the corrosion occurs in the neighborhood of the power station and close to the return connection-points. [For further particulars see the original table and report of Prof. Teichmüller.]

The Commission has engaged Mr. Max Spindler to carry out the second task imposed upon it, viz., the special measurements.

The town of Elberfeld, where the Gas and Water Works and a large portion of the electric trams are municipal, appeared to offer a field particularly well suited for these measurements. Moreover, Elberfeld offers the great advantage of possessing an extensive system of test wires, in connection with its electric light cables, by means of which the potentials of the rails, with reference to the negative bus-bar, and with reference to a point in the soil favorably connected to the surface water near the central station, could be ascertained with accuracy.

Mr. Spindler has recorded the results of these tests in a detailed report with sketches attached, and attention is directed to this original report.

Following is a brief statement of the nature of these tests:

After making a number of preliminary trials, this order for the final measurements was decided upon.—First, the potential of the rail network was determined relative to the negative bus-bars and relative to the soil near the central station; secondly, the difference of potential between the network of rails and the network of pipes was ascertained by individual measurements spread over the entire district.

As a result of this general investigation, characteristic points were selected where the strength of the current flowing through the pipes was determined by a special method of testing.

As a further preliminary, a number of measurements were made to determine the resistance of pipes of different cross-sections, with and without spigot and socket connections, before as well as after caulking, and also after filling in and stamping down the earth in the trench.

These demonstrated that the resistance of a system of piping depends to such a large extent on the condition of the joints, and on the amount of metallic contact in the sockets, that not even approximately correct figures can be assumed, but that the resistance of each length of pipe under consideration must be measured separately.

A second series of preliminary tests was made at hydrants, house services, etc. In these it was found that only the hydrants make suitable connections, and those only for voltage measurements; for current measurements, it was found essential to make direct connections with the pipe in question.

The results of the measurements can be combined under the following headings:

(A) Methods of Measuring.
(B) Danger and Corrosion.
(C) Protective Measures.

(A) Methods of Measurements.

First of all, the electrical relations of the network of rails to the network of pipes should be determined and recorded in the most complete manner. For this purpose, the difference of potential between the rails and the negative bus-bar during the period of full load on the tram lines must be determined at a large number of places and at all characteristic points (points where the return lines are connected, points likely to have the highest rail potential, etc.), and a graphic representation of the distribution of the potential in the rail network must then be made.

Special test wires should be used for this purpose, although, if necessary, telephone wires can be used temporarily. The measurements of voltage between the network of rails and the ground possess less value because the potentials of the ground-points vary in the same way (although in less degree) as the potentials of the rails.

Where possible it is also desirable to determine at numerous points the potentials of the pipes with reference to the negative bus-bar.

The difference of potential between the rails and the pipes

must also be determined at as many points as possible, especially at all characteristic points. In this case, it is advisable to make the measurements at the water pipes, for which purpose the hydrants should be used for making contact.

The graphical representation of the results obtained by these measurements furnishes a clear idea of the course of the potential of the rail network on the one hand, and in the rails with reference to the pipes on the other hand; and shows whether the installation for returning the currents is properly designed and operated. It also shows where the particularly endangered zones of the pipes are located, what defects in the arrangement of the return lines cause this danger, and how the trouble can be prevented.

It can be seen from the chart in which districts the pipes have a higher potential than the rail system; that is, in which districts current passes from the pipes to the earth or to the rails. Likewise, points can be indicated where the potential of the pipes is negative to the rails; also where there is an escape of current from one main into another or into ground of especially good conductivity.

In connection with this graphical representation, the voltage can also be determined between a number of hydrants in districts where the rails are negative to the pipes or where unusual phenomena make such measurements desirable. The hydrants used for these determinations must be so selected that the stretches of pipes between them are continuous without other pipes branching off. The difference of potential should be first determined when the railway service is suspended, and then again when the railway is in full operation.

These measurements furnish a reliable basis for obtaining the direction of the currents in the pipes, and taken together, make it possible to locate approximately the points of escape of current. In consequence of the results of these general measurements, the actual measurements of the currents in the pipes can be limited to a few places. The most suitable practical method for this purpose was to expose the pipe at three selected points which were from 65 ft. to 100 ft. apart, and, while the service was suspended, to determine the resistance of the two included lengths. When the railway was in

operation, the currents in the pipes could then be determined with sufficient accuracy by measurements of potential differences.

(B) Danger and Corrosion.

These results can be regarded from two points of view:

1. *The Special Results of the Elberfeld Measurements.*

2. *The Generally Applicable Results which can be deduced from* 1.

1. *The Special Results of the Elberfeld Measurements* can be summarized as follows:

(a) Electrical Conditions.

The maximum difference of potential between two points of the rail network was from 3.5 to 4 volts. (The Croneberger road is not included in this because measurements could not be made there owing to the absence of test wires.)

Currents up to 3 amperes were found by measurements on the pipes. It has been proven that, under certain circumstances, current escapes from the pipes to the earth, or to other pipes through which the current continues, even in districts where the pipes are negative to the rails.

Wherever pipes cross there is more or less escape of current from one to the other, as small potential differences usually exist between different pipes.

The passage of currents from the pipes is spread over a comparatively large district and seems to be strongest near the connection-point of the return conductor closest to the electric power station.

The return cables do not produce equal potential at the connection-points in the rails, as these cables are not proportioned to the strength of current which they carry during the present service.

By the insertion of adjustable resistances in certain of the return lines improvement could soon be secured.

By increasing the number of return cables the differences of potential in the rail network can be further reduced and limited to any desired degree.

(b) Damages.

A gas pipe, which was situated near the rails not far from

the first return connection, was badly oxidized on its entire circumference in consequence of the escaping earth currents. The oxides acted on the surrounding soil for a distance of more than ¾ of an inch. The surface of the iron itself was changed, to some extent, into a soft graphite-like mass.

The other pipes in this vicinity, which were deeper down in the ground and further removed from the rails, were found to be in good condition, but at a point where these pipes cross the upper pipes there was corrosion. This indicated that an escape of current from the lower into the upper pipes and from these to the soil and into the rails was actually taking place, and this was confirmed by a current measurement.

It must be borne in mind that these damaging influences had existed only for the short period of a few years.

2. *The Generally Applicable Results:*

Such pipes are most endangered which form a connection between rail districts possessing a high potential and those possessing a low potential, or which connect points having a good conducting medium through the earth with other points of very different potentials.

The danger district is generally near the connection-points of the return lines or near similar points of low potential. The location of the endangered areas also depends considerably upon the resistance between the pipes and rails as well as on the chemical composition of the soil.

Other endangered points often occur where two pipes are either close together or cross each other, thus forming a connection between points of higher and lower potential.

Points are particularly in danger where the pipes cross the rails in districts where the potential of the pipes is positive to the rails.

The composition of the soil as well as the local conditions (water in the soil, etc.) have a strong influence on the degree of danger.

(C) Protective Measures.

The "Regulations" issued by the Commission are given on pages 893 to 899. (Signed) W. H. Lindley,

Frankfort-on-Main. *Chairman.*

The List of Questions

referred to in the foregoing Report, issued by the German Electrolysis Commission in 1904:

1. When was the electric tramway service started in your city?

2. What is the nature of the return circuit? (*a*) Are the rails used without auxiliary cables? or (*b*) Are auxiliary cables used, and are these insulated or uninsulated? What is the cross-section of these return feeders relative to the outgoing feeders?

3. Were return feeders installed when the road was first put in operation or were they added at a later time, and, if so, about when were they added, and for what reason?

4. Have any arrangements been introduced in the power house or in the rail network for the purpose of diminishing the potential differences between different parts of the grounded rail network? If so, what are these arrangements, and when were they installed?

5. Have you noticed any electrolytic destruction of water or gas pipes, and if so, of which pipes?

6. If so, what evidence is there to indicate that the destruction was due to the return current from the tramway, or can the destruction be otherwise accounted for?

7. Have you noticed that the destruction is more especially confined to certain parts of the pipe network? If so, which sections or points have been most seriously affected?

(Note: If possible a plan of the city showing the piping system and the points of destruction should be added.)

8. Has the destruction been particularly severe in any one section of the city, and, if so, how do you account for this? Can the conclusion be drawn that in this section a peculiar condition of the soil exists, and if so, what is this condition?

9. Have you noticed whether the destructive influence is greater with conductors of a certain material, and, if so, with what material?

10. If your answer to (5) is "no," have you, for any other reason, investigated the question of electrolytic destruction, and have you made any observations or measurements in this connection?

11. What results and conclusions have you obtained from your observations and measurements?

12. Does the soil in your city contain characteristic chemical constituents, such as chlorides, sulphates, etc., which might attack the pipes or favor Electrolysis from railway return currents?

13. If you cannot prove that the damage to your pipes was due to Electrolysis, has the damage to the pipes increased largely since the electric tramway has been in operation?

14. Can you give the approximate number of annual repairs which were made to your piping system for a period of say three or five years before and after the electric tramway service was started?

The Regulations

referred to in the foregoing Report, issued by the German Electrolysis Commission in 1904:

REGULATIONS FOR THE PROTECTION OF GAS AND WATER PIPES AGAINST THE DAMAGING INFLUENCES OF STRAY CURRENTS FROM DIRECT CURRENT ELECTRIC RAILWAYS USING THE RAILS AS RETURN CONDUCTORS.

1. *Current Supply.* The trolley wire is to be connected to the positive pole, and the rails are to be connected to the negative pole of the generator by means of insulated cables.

2. *Rail Network.* All rails which are used for the return current are to be made as good and reliable conductors as possible. To this end:

(*a*) If the rail joints are not welded, they must be permanently bonded by means of copper wire not less than 8 millimeters in diameter. This rule applies also to cast joints. The resistance of the finished track is never to be more than 20 per cent. higher than that of an unjointed track of equal length and section.

(*b*) The rails of a track must be connected, at least every 50 meters, with a cross bond similar to that at the rail joints; adjacent tracks must in addition be cross-connected, every

100 meters or less, with a bond wire of at least twice the cross section of the other bonds.

(*c*) The track must be provided at all crossings and switches with connecting bonds, constructed in accordance with Rule 2a, which completely bridge the switch or crossing with a good conducting connection.

(*d*) At all movable bridges and at all other points where the tracks are interrupted, the separate portions of the track must be connected by insulated cables of suitable size to insure the permanent electrical continuity of the track system.

3. *Potential Difference in the Rail Network.* The potential difference in the rail network must be limited to a certain prescribed amount, which must not be exceeded with the greatest or most unfavorable loading of the return circuit.

The greatest permissible potential difference must be determined for each place separately, for it depends upon local conditions, such as the nature of the soil, the location and resistance of the pipes between points of highest and lowest potentials, the position of the pipes with respect to the rails, etc. In special cases, this greatest permissible potential difference may be different in different sections of a rail system.

For the present this maximum permissible potential difference in the rail network may be taken as *one volt;* this figure to be the average of readings taken for ten minutes during a period of full load.

4. *Return Conductors.* Where the rails alone are not sufficient for the return current, without allowing the potential difference to exceed the prescribed amount, extra return conductors must be provided.

These return connections must be so numerous and so planned that, in conjunction with good conductivity of the rail network, they prevent the potential difference in the rails from exceeding the prescribed amount.

The points where the return conductors are connected to the rails should be located as far from the pipes as possible.

The return conductors must be insulated and of sufficient size to return the current with only a small drop in voltage; so that, if an occasional change in the distribution of the

currents occurs, no excessive difference in the potentials at the connection-points of the return conductors will be produced.

The return conductors should have a cross-section at least equal to that of the outgoing conductors; where conditions require a number of return conductors, it may be better to make them of larger cross-sections than the outgoing conductors.

5. *Return Connections for Auxiliary Installations.* Stationary motors and electric lamps, which are supplied from electric railways employing the rails for the return current, must be connected to the return conductors or to the rails by means of insulated cables; but the potential difference in the rails must not be increased thereby above the permissible limit given in Rule 3. It is not permissible to connect one pole of such a motor to the ground by earth plates or otherwise. The frame of the motor must be grounded, but must not be connected to one pole of the motor.

6. *Adjustability of the Return Conductors.* An essential condition for minimizing the potential difference in the rails, and therefore the stray currents, is that the potentials be equalized at all points where return conductors are connected to the rails. The resistance of each return conductor must, therefore, be proportional to the strength of current which it has to carry. For this purpose, each return conductor must be provided with an adjustable resistance (or negative booster,) so that the product of current and resistance may be made the same for all return conductors.

7. *Negative Boosters (Sucker Dynamos).* Negative boosters are to be recommended, particularly for the purpose of automatically regulating the rail potentials at the connection-points of the return conductors in districts where the return conductors are liable to be frequently or seriously overloaded.

8. *Controlling Arrangements.* Test wires must be led to the distributing station from all points where return conductors are connected to the rails, and from all points of relatively highest potentials in the rail network (points between two return connections and points at the end of the track). By connecting a voltmeter, it must be always possible to determine the potentials of these points in the rails. Arrangements

must also be provided so that the current in any one of the return conductors can be measured at any time. Whenever the opportunity occurs, test wires should be attached to characteristic points in the piping system. These test wires should terminate in small boxes attached to near-by walls, so as to be always available for measuring the potential differences between the pipes and the rails and the currents in the pipes; these wires should be carefully protected.

9. *Resistance Between Rails and Earth.* The resistance between the ground and rails carrying return current must be kept as high as possible. When this resistance is not sufficiently high, owing to conditions of the ground or of the road-bed, special steps must be taken to increase it by means of suitable insulation. To accomplish this it is recommended that the rails be laid upon a dry bed of broken stone or gravel, or upon a layer of poor conducting material; or upon a concrete foundation at least 25 centimeters wide and 15 centimeters thick, having on top of it a layer of asphalt at least 1.5 centimeters in thickness and projecting not less than 5 centimeters at each side of the rail.

The dryness of the earth about the rails is an important element in this resistance. For this reason it is of great importance to render the road surface between and near the rails impervious to water, and to drain the sub-soil. To make the road-bed water-tight, it is best to finish it with asphalt, or with stone or wood pavement set and grouted in asphalt, for a distance of at least 50 centimeters beyond the outermost rails.

Metallic connections between the rails and the earth, by means of earth plates and the like, or between the rails and subterranean metal not belonging to the tramway network, reduce the resistance between the rails and the earth and must not be permitted; wherever existing, they must be removed. The use of salt to thaw snow and ice is injurious and should either be entirely prohibited or permitted only in case of emergency.

10. *Connections between Rails and Pipes.* Metallic connection of the pipes with the rails or with the return conductors or with the negative bus-bar must under no circumstances be permitted, and must be removed wherever

present. Such connections bring the pipes in parallel with the rails or return conductors and produce destructive actions at the invariably numerous points of imperfect contact in the pipes, such as in joints, valves, etc.

11. *Distance between Rails and Pipe Fittings.* The shortest permissible distance between rails and such fittings (hydrants, stop cocks, etc.) as are in metallic contact with the pipes and reach or approach the surface of the road, is *one* meter. Where this distance is less, the fittings should be transferred, or, if this be not possible, the electrical connection between them and the upper layer of earth must be interrupted by earthenware covers or brickwork, or in some similar manner.

12. *Protective Devices for Pipes.* Pipes which cross under the rails should be insulated for a distance of at least one meter beyond the outer rails, or they should be provided with auxiliary covering pipes, in good metallic contact with the pipes proper, through which the electrical connection to the earth is made. Where two pipe systems cross or approximate each other, they should for mutual protection be metallically connected together wherever other conditions permit (that is, where the potential differences involved are slight, etc.).

13. *Application of the Rules.* These Rules either do not apply, or apply only to a limited extent, to electric railways outside of the gas and water districts.

14. *Examination of Existing Installations.* With regard to existing electric railways, tests should be made of the electrical conditions of the rails and return conductors under full load operation, in order to determine to what extent they fulfill these requirements.

The following conditions, particularly, should be determined:

(*a*) The potential differences between the negative bus-bar and the various characteristic points in the rails, *i. e.*, points where return conductors are connected, points of relatively highest potentials, etc.

(*b*) The potential differences between the points mentioned in (a) and a suitable earth connection lying in ground water.

(*c*) The potential differences between the negative bus-bar and a number of characteristic and suitably distributed points in the pipe network.

(*d*) The potential differences between the rails and the gas and water pipes at the above mentioned points. It is advisable to make these measurements at the water pipes, and either directly on the pipes or on a hydrant ; valve spindles do not offer sufficiently good contact for this purpose.

The results of these measurements are best plotted on a plan of the tramway system. The potentials of the rails, with reference to the negative bus-bar and to the pipes, should be indicated on this plan ; and the zones should be determined in which the pipes are positive to the rails, and where currents are likely to pass from the pipes to the earth and to the rails. The potential differences between suitable points in the pipe network (hydrants, etc.) should be determined, first, when the tram-service is suspended ; and, secondly, when it is in full operation. From these results the direction of the currents in the pipes can be ascertained, and the districts can be approximated where current is leaving the pipes. In connection with these tests, the strength of the currents in the pipes can also be determined where necessary. In districts where the pipes and rails approximate or cross each other, and in the neighborhood of the return connections, excavations should be made, and the condition of the pipes should be determined by inspection. Then, it must be estimated at what crossings or points of proximity currents are likely to pass from one pipe to others, either belonging to the same or to another piping system. At such points, also, the pipes should be uncovered and inspected, and the potential differences should be measured when the tram-service is in full operation.

The above will serve as a basis for deciding what protective measures should be employed locally for the preservation of the pipes.

By promptly installing the adjustable resistances in the return conductors specified in Rule 6, and also the measuring arrangements specified in Rule 8, it is probable that very considerable improvement in the electrical conditions in many installations can be soon obtained.

15. *Control During Operation.* During the operation of the road, and particularly during times of greatest or most unfavorable load, the distribution of potentials in the rails

must be regulated as required. The resistances of the return conductors are to be adjusted so that the potentials of all points where the return conductors are connected to the rails shall be as nearly equal as possible. The strength of current in each return conductor should also be adjusted at the same time. Such adjustments are especially to be made whenever there is a change in the traffic condition.

Whenever the insulation of the lines is measured, or at least twice every year, the resistances of the rail joints should be measured, by means of a bond tester (differential voltmeter), to see if they meet the requirements of Rule 2a.

The measurements made at the station before and after adjusting the resistances, and other tests, as well as the resistances of the rail joints, are to be recorded on a sheet which must be open at all times to the inspection of the gas and water officials.

Discussion

of the foregoing Report and Regulations by the Chairman of the Commission at the Annual Meeting of the Society in 1904:

[*Condensed Translation.*]

Briefly, in regard to the list of questions, the following remarks may be made:

Of the 130 answers received referring to 113 cities, 109 possess electric railway systems. Of these 56 per cent. make use of the rails without return conductors, 37.5 per cent. make use of the rails and insulated return conductors, and 6.5 per cent. make use of the rails and uninsulated return conductors.

The question whether electrolytic destruction had been observed was denied in most cases, and only 14 cities, or 13 per cent. of the total, answered this question affirmatively. From these denials the conclusion cannot, however, be drawn that no destruction had occurred in these cities, for later, upon uncovering the pipes in some of the cities which had answered in the negative, considerable damage was found. In some

cities having water and gas systems independent one of another, the one commissioner had answered the question affirmatively and the other negatively.

A glance at the answers to the question regarding the condition of the return system shows that these are generally poor, and that the question of protecting our water and gas piping through suitable devices applied to the return system of electric railways has not received sufficient attention.

Under these conditions, the fact should be again emphasized that the many denials of damage cannot be considered final. We are dealing with return currents which must largely pass through the ground, and which will naturally pass through our pipes, these being good conductors. Under certain conditions of the soil and water, and with suitable positions of the pipes relative to the rails, these stray currents must produce destructive influences. It is, therefore, only the intensity of these currents which determines the time in which the destructive effects will become evident.

As the thickness of the water pipes is not based on the internal pressure used, but is made much heavier for practical purposes—especially in the case of the smaller sizes which are made several times heavier—these pipes are able to stand this gradual deterioration for a number of years. However, even where the action is very slow, its effect will in time make itself evident.

The long list of tests at Elberfeld shows the resistance of different kinds of pipes, and has developed correct methods of measuring, the details of which would exceed the limits of this paper. The potentials at different points of the track relative to the minus pole of the dynamo were measured, and the potential differences in the track and in the return conductors were thus ascertained. The potential differences between the piping system and the negative pole of the dynamo, and between the pipes and the track, were also determined at different points, as well as the potentials of the track relative to a neutral ground point.

The differences of potential between the track and the piping system were then laid out on the city map. The curve

through these points has a width equal to the maximum potential difference and crosses the track line where the potential difference is zero; positive readings, where the current flows from the rails to the pipes, were laid off on one side, and negative readings, where the current flows from the pipes to the rails, were laid off on the other side of the track lines. The latter places indicate where disturbances are to be looked for. From such curves the points of greatest potential difference and their location on the track system may be readily seen, and the danger sections may be readily marked on a map which shows the relative positions of the tracks and the pipes. The pipes in these places of probable greatest destruction should be examined.

It was, at first, the opinion of the Commission that it could determine only general points of view. After careful discussion, however, only one point appeared to be left which was really in doubt, namely, the greatest permissible potential difference between the track and the pipes—in other words, the highest potential difference in the track system, at which it may be assumed that no destruction will occur.

The Commission is not yet able to present a definite proposal on this subject. In fact, no universal rule can ever be given, because the permissible potential difference depends largely upon local conditions. The potential difference in itself is not the determining factor, except insofar as it determines the strength of the current, which, in turn, depends on the resistance of the earth and of the piping system; and this resistance is a variable quantity, depending upon the degree of dryness or dampness, the chemical and mechanical composition of the earth, and the distribution of the piping system. Several years of investigation under the various conditions will probably be required to reach satisfactory conclusions regarding this question, and even then it will not be possible to issue definite rules which can be universally applied, but only to give to the administrations concerned such information that they can determine for each place the permissible potential difference best suitable to the local conditions.

The Commission believed that its object would be best

promoted by presenting its recommendations in a Set of Regulations designed to improve the existing conditions, leaving the question of the highest permissible potential difference at which there would be no destruction to be settled at a later time. This leaves a gap which at present we can bridge only temporarily, but which every one will be able to fill in for himself later on. These Regulations (see pages 893 to 899) will now be briefly discussed :

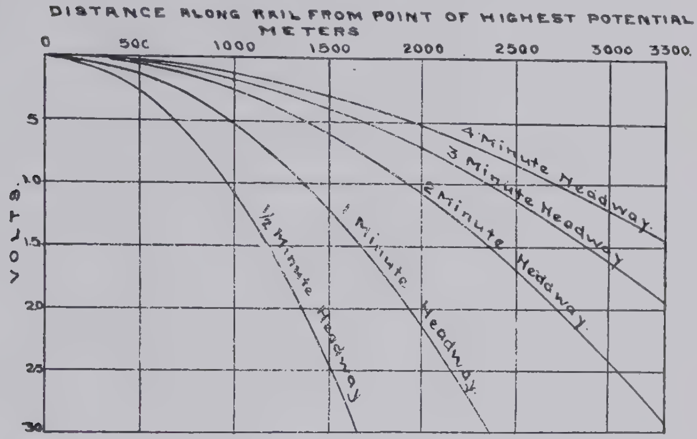
Paragraph *One* requires that the trolley wire should be connected with the positive pole, and the rails with the negative pole of the dynamo.

Paragraph *Two* requires, above all, that the rail system be a good conducting medium, and that the rail joints be connected by copper bonds so that they should form a perfect electrical connection even if a loosening of the rail joints should occur. It also states that the resistance of the entire track must not exceed the theoretical resistance of the two uninterrupted rails by more than twenty per cent. The cross-connections insure that if one line of rails should be interrupted, the other could then do its work without an undue increase in potential.

Paragraph *Three* requires that the potential difference in the track shall not exceed a certain small amount. By this difference is meant the difference in potential between a return point and the point of highest potential between two return points, or between a return point and the furthermost end of the track system. As before mentioned, the Commission cannot propose a final and generally applicable value for this greatest permissible potential difference ; but, as it appeared necessary for existing electric roads and those under construction to have some information regarding this point, the Commission proposes that the highest permissible potential difference in the track system be placed at *one volt*, this to be the average reading at full load for a period of about ten minutes.

In order to illustrate the drop in a track system under different traffic densities, the accompanying diagram has been prepared.

CURVES SHOWING VOLTAGE DROP IN A DOUBLE TRACK SYSTEM USED FOR THE RETURN CURRENT WITH DIFFERENT TRAFFIC DENSITIES.



Assumed Figures.

Resistance of 1 kilometer of single rail...... .036 ohm.
" " 1 " " double track.... .009 "
Average current used by one car....... 16 amp.
Average speed of car................. 16 km. per hour.

Distance between cars on the double tracks.	with ½ minute headway .67 meter.
	" 1 " " .133 "
	" 2 " " .267 " etc.

The curves are calculated for cars running under one-half, one, two, three and four minutes headway on each track, and start at the point of highest potential between two return points. These curves show the relation of the distance between points of return connection and the highest permissible potential difference, with different traffic densities.

The potential difference of one volt is obtained under the following conditions:

With ½ minute headway at 1900 meters between return points.

With 1 minute headway at 2700 meters between return points.

With 2 minutes headway at 3800 meters between return points.

The diagram shows that the increase of the permissible potential difference to two volts causes only a small increase in the distance between the return points, i. e.,

With ½ minute headway only from 1900 meters to 2700 meters.

With 1 minute headway only from 2700 meters to 3800 meters.

With 2 minute headway only from 3800 meters to 5400 meters.

These distances between connection-points for a drop of one volt should demonstrate that this demand for the track return equipment is not unreasonable.

Paragraph *Four* states that special return cables must be installed, if the track system is not in itself sufficient to carry the return current with the drop limit of one volt; and that these, in contrast to many present installations, must be insulated.

Paragraph *Five* requires that the resistance of the return conductors be made controllable. It is remarkable that this is not the case in a great many electric railway installations. If the object which we have in view is to be attained, namely, to reduce to a minimum the potential differences in the track system, which are the cause of the stray currents, then, above all, we must be able to control the potentials at all of the points where the return conductors are connected to the rails so as to keep these return points at the same potential.

Paragraph *Six* proposes, in special cases, where the conditions of traffic make it desirable to overload a particular return conductor either temporarily or permanently, but where it is undesirable to raise the potential of the entire track system, to use a negative booster to lower the potential at the point where this particular return conductor is connected to the rails, and thus artificially induce the current to return by this conductor to the negative bus-bar.

Paragraph *Seven* requires special test wires to be led to the central station from all points where the return conductors are connected to the rails and from all presumptive points of

highest potential in the rails, arranged so that the potentials at these points can be observed and regulated accordingly.

In this way the changes of potential in the track system, due to changes in traffic on Sundays, holidays and special occasions, can be detected, and the resistance in the return cables regulated so that even under these conditions a nearly uniform potential at the return connections can be secured.

Paragraph *Eight* deals with the return conductors for auxiliary installations such as motors, lights, etc., and requires that in such installations the negative terminals be connected to the rails or to the return conductor, by means of insulated cables.

Paragraph *Nine* deals first with the resistance between the rails and the ground, which is one of the most important questions. If it were possible to insulate the track from the earth, an ideal condition for the protection of the piping system would be obtained. As this is not possible, the resistance between the rails and the earth should be kept as high as practicable by means of sand, gravel and broken stone placed around the tracks, and by making the surface water-proof, etc.

Other recommendations are given in this paragraph: Minimizing the use of salt for thawing purposes is advised, because the salt water penetrates into the ground and produces a higher conductivity. Wherever this brine reaches the pipes an increased danger is produced, so that the Commission proposes either to entirely prohibit the use of salt or to limit its use to emergency cases. Above all, the frequent mistake of intimately connecting the rails with the earth by means of earth plates must be rectified. This arrangement is so manifestly wrong that it does not seem possible that anyone should favor it. It must, therefore, be absolutely demanded that no such connections be made, and that those already existing be promptly removed.

Paragraph *Ten* deals with connections between pipes and rails. The pipes and the rails have been sometimes metallically connected at the points where the current leaves the pipes and passes back to the rails, because the most harmful effects exist at these points, and it was thought that such connections

might remove the danger. This would be reasonable, if it were not for the fact *inter alia* that a poor contact is obtained at all hub and spigot and other pipe connections, and at these points the current causes immediate electrolytic action. With such metallic connections, that particular section of the pipe is placed in parallel with the rails, the current carried by the pipes is proportionately increased, and, instead of having one place of current leakage, we obtain many points where the current passes into and out of the pipe. It is therefore requested that this class of metallic connection be avoided, and that the existing ones be removed.

Paragraphs *Eleven* and *Twelve* advise as great a distance as possible between the pipes and the rails, and, where necessary, the application of special protective devices to the pipes.

Paragraph *Thirteen* describes the railways to which these Regulations are applicable.

Paragraph *Fourteen* deals with the Elberfeld measurements and tests. This paragraph also describes how to obtain a curve for any given city, which readily shows the potential difference between the piping and the tracks, and the *danger* territory; i. e., a curve which will indicate all points of the system where the most damaging influences exist.

The *Fifteenth* and Last Paragraph requires that these Regulations should be observed not only when the railway is first installed, but constantly observed during the operation of the road. This assures that the required conditions are permanently maintained, and that improper conditions, due to changes in the traffic and in the distribution of the load, or owing to increased resistance in the track system or other causes, cannot exist unnoticed for any considerable time.

Report of the Electrolysis Commission

of the German Society of Gas and Water Engineers in 1905.

[*Condensed Translation.*]

The following is a report of the work carried out during the year from June, 1904, to June, 1905:

1. PROGRAM OF THE WORK.

As is seen from last year's report the Commission concluded that the principal cause of earth currents, and with these the possibility of severe and rapid electrolytic destruction of pipes, is the unsuitable conditions of return circuits in electric tramways. Hence, the Commission's first task was to investigate the electrical conditions of the pipes and rails in various characteristic towns, and, where necessary, to find means to limit the danger of the earth currents as much as practicable. The task was, therefore, primarily an electro-technical one.

The following necessary preparations were made during the previous year:

1. Collection of current information from the managers of the different gas, water, and electrical works, by means of a circular letter containing a detailed set of questions.

2. Development and testing of methods of investigation.

3. Tabulation of rules, for temporary guidance, developed from previous experience and especially from the results obtained at Elberfeld where the first investigations were carried out last year.

It was intended, after preparation, to continue these investigations this year in other towns, in order to collect as complete a set of experimental facts as possible.

2. CHOICE OF PLACES FOR INVESTIGATION.

In selecting the places for Electrolysis investigation those were considered in which the installations promised characteristic results, or where unusually severe corrosion had occurred and a thorough investigation seemed therefore desirable to clear up questions of general importance and to promote local interests. Also places were considered where the authorities, realizing the importance of this work, had applied to the Commission for information regarding the condition of their pipes, and of the means available for removing or diminishing any existing danger.

At the following towns tests have either been completed, or are still partly in progress, or negotiations for such tests have been begun:

Strasburg, where corrosion of the water pipes had been observed, and an investigation was desired by the municipal authorities.

Dresden, where particularly interesting and instructive conditions were to be expected, owing to the use of bare return conductors.

Leipzig and *Hamburg*, where rules for the protection of the pipes were in force, which were in many respects similar or equivalent to the Regulations of the Commission, so that such tests promised to determine the effectiveness of these protective measures.

Erfurt, where particularly severe corrosion of gas pipes had occurred.

Freiburg in B., where the management of the municipal gas, water, and electrical works requested the Commission to test the return conductors and pipes, although no corrosion had yet been noticed.

The resumption of the work was delayed until the end of November, 1904, owing to the resignation of the engineer, Mr. Max Spindler, who had carried on the preparations and investigations at Elberfeld last year. This made it necessary to secure in his place Mr. Friedrich Besig, who was not free to serve the Commission until that time.

Strasburg was chosen as the first place for investigation; work was begun there in the beginning of December, 1904, and lasted about 8 weeks. Dresden followed Strasburg, and here the investigations occupied about the same time. The discovery of corrosion at Strasburg, some time later, induced the municipal authorities to apply again to the Commission, which accordingly sent its engineer to Strasburg for a second time in search of new developments.

3. PRINCIPAL RESULTS OF THE INVESTIGATIONS AT STRASBURG AND DRESDEN.

The results are collected in two detailed reports, with drawings and diagrams, and were communicated to the board of the Society and to the administrations of the towns concerned. The reports, with all the appended drawings, are

too extensive, however, for immediate publication. The work of the Commission, when completed, will be published in detailed and collected form; but only the principal results of these researches can be given at the present time.

(a) *Tests at Strasburg.*

The voltage measurements in the network of pipes and rails showed abnormally high maximum values. These were:

Close to the generating station an average of 2.2 volts (periodically) and a maximum of 2.8 volts between the pipes and rails, the pipe being positive relative to the rails.

At a great distance from the station, there was an average of 4 volts and a maximum of 11.5 volts, the pipe being negative relative to the rails.

The important direct measurements of the potential differences between the connection-points where the return conductors are connected to the rails could not be made for want of a sufficient number of test wires between these points and the central station. The return conductors were, it is true, provided with test wires, but nearly all of these were useless in consequence of breakage or of failure of the insulation. This again proves with what little consideration the return conductors have been treated by many electric railways, and how important it is to draw their attention to this point.

In making such tests the lack of suitable controlling arrangements is unpleasantly felt. Much time is consequently wasted, and it is necessary to employ indirect methods of testing, which are much less accurate than direct voltage measurements. At Strasburg, the strength of the current in the return conductors was measured, and the resistances of these lines were calculated from the sections and lengths which were furnished by the authorities. The product of the current and the resistance of the line gives the drop in voltage, and the differences in the drops of the individual return lines give the potential differences between the various connection-points.

According to the protective Regulations laid down in 1904, (Rule 6, page 139) these differences should be practically nil; at Strasburg, however, under the existing conditions, these differences reached 6.5 volts.

This unfavorable result is not a consequence of insufficient

return lines nor of insufficient cable cross-section. The return wires have in fact the same cross-section as the outgoing supply wires, and they are connected to the rails at all points where the outgoing wires are connected to the trolley wire. (This arrangement is often chosen because it makes it possible to replace temporarily the positive feeder cable by the return cable in case of defective insulation.)

The result mentioned is, in this case, due to the lack of the proper relation between the resistance of the individual return cables and the current which they carry, and is especially due to the short and large return conductor of very low resistance which connects a point close to the central station directly to the negative bus-bar.

Currents up to 1 ampere were measured at several places in the pipes; these occurred only during the operation of the electric traction service and were, therefore, tramway return currents. Under suitable conditions of current density and soil such currents will cause considerable corrosion where they leave the pipes.

A clear impression of the efficacy of the return lines was obtained by measuring the current in the single return lines simultaneously with the current in the corresponding supply wires. It was found that although the currents in several of the return lines varied little from those in the outgoing lines, which is generally speaking the normal and suitable condition, yet in the very long and very short cables extreme differences between return and outgoing currents were observed. In the longest return cable the current was found to be less than one-third, while in the shortest return cable it was found to be more than four times the corresponding outgoing current.

This corresponds with the extreme differences of potential between the connection-points of the return conductors. If a return connection-point remote from the central station has a higher potential than one close to the station, the current from the remote section will be returned only in part through the long return conductor, the other part being returned by the rails and the ground to points of low potential near the central station.

The rail bonds in the Strasburg system were examined at a number of points by means of the bond-testing apparatus. This showed that the percentage increase of resistance of the rails due to the bonds varies considerably, in some cases up to 100 per cent. The bonds made by the thermite process of Dr. Goldschmidt and those electrically welded (though in use only a short time) gave good results, as their resistance in many cases was practically equal to that of the continuous rail.

An important result of the Strasburg experiment was the confirmation of the value of Rule 6 of the protective Regulations, regarding the equalization of the potentials at the return connection-points. By simply inserting a small resistance in the shortest return cable, the maximum difference of potential between two return connection-points was immediately reduced from 6.5 to 2.8 volts, and the difference of potential between the pipes and the rails was reduced in the whole system to an average of about one-half of the former amount.

This method is without doubt particularly effective ; and, by inserting variable resistances in all the return lines and testing and adjusting at regular intervals, conditions can be secured in the Strasburg pipes which will cause the present unfavorable differences of potential to disappear, and reduce the danger of the corrosive action of the tramway return currents to a small amount.

A careful observance of these suggestions is particularly important in the case of Strasburg, because the nature of the soil and high level of the ground water appear to favor the conductivity and electrolytic action of the ground.

The special electro-chemical researches which are being made with reference to this last feature have not yet been completed, and the Commission will give further information on this point in the next report.

b. Tests at Dredsen.

The experiences gathered in Strasburg apply in many respects to Dresden. In this case, also, the return wires were connected to the rails close to the electric power station. As there are,

however, two central stations supplying current, the distribution of the potential differences between the pipes and the rails differs in its graphical appearance from that observed in Strasburg and Elberfeld, but is the same in principle. In Dresden there are two regions of lowest potential, one in the neighborhood of each central station, where the potential of the pipes is higher than the potential of the rails; these are, therefore, danger zones for the pipes.

The main difference between the return line installations at Dresden and those at Elberfeld and Strasburg lies in the use of uninsulated return wires, which, although cheaper, are not as effective for the protection of the pipes as are insulated return wires.

An uninsulated conductor laid in the ground is in contact with the ground along its entire length, and imparts its own potential to the ground; the two, therefore, behave like two electric conductors connected in parallel at an infinite number of points. Hence, the drop in potential, with the practically perfect contact existing, must be nearly the same in the soil surrounding the cable as along the cable itself.

The uninsulated return conductors in Dresden are, as a matter of fact, placed in a brick conduit which is filled with earth. This brickwork is, however, not water-tight, many bricks having been broken during construction, and the moisture of the ground easily penetrates this conduit, making a good conductor at many points between the layers of soil inside and outside of the conduit.

In this way the rails, the return cables, and the soil form three parallel conductors between which the return current divides in proportion to their conductivities. While, then, the main function of the return conductors should be to lead off all the currents which come together at the point of connection to the rails, in Dresden they serve, notwithstanding the high conductivity of copper, only to slightly increase the rail section, on account of their small cross-section as compared to that of the rails. This is particularly the case in those districts where the return cables run parallel to the rails for long stretches (as with almost all of the Dresden lines) and are especially well connected electrically to the rails about every

300 feet. Therefore the Dresden return cables do not prevent what they are intended to prevent, namely, a gradual increase in the current returned by the rails from the ends of the system to the central station, and a corresponding parabolic increase in the fall of potential along the rails. The result is that in the vicinity of the central station, even with excellent rail bonding, large differences of potential are certain to occur in the rails, and for this reason also in the soil and pipes.

In this way the potential differences in the rails in Dresden gradually increases from 0 to about 5 volts per kilometer of rail length.

The differences in potential, and hence the currents in the pipes, increases in a similar manner. Several pipes carry very large currents; for instance, a trunk gas pipe carried about four amperes. This unusually large return current is explained by the fact that Dresden is separated into two separate systems of street pipes by the Elbe. Since both central stations are located in the district on the left side of the Elbe, all of the stray currents which enter the pipes in the district on the right bank collect in the few trunk pipes which cross the Elbe.

The largest potential differences, between pipes and rails of the dangerous kind, *i. e.*, where the pipes are positive to the rails, occur in the vicinity of the central stations close to the connection-points of the return lines, as well as near the short uninsulated return wires which connect with the negative bus-bars in the stations. These amount to about 3 volts.

Corrosion has hitherto been noticed only in lead house service connections which cross the rails, and this corrosion is confined to the immediate vicinity of the old power plant which exists since 1893. In the neighborhood of the new power station, put in operation in 1900, nothing conspicuous has been noticed up to date. The uninsulated lead pipes apparently form a good conductor which lead off the current from the soil and in this way protect to a certain degree the iron pipes. Traces of corrosion on these latter were also, however, observed when a pipe was exposed in order to measure its resistance; these pipes, too, were close to the older power plant.

The pipes in Dresden as well as those in Strasburg were also tested during the night. The potential differences and currents (natural earth currents and those caused by local action) which were observed when the tram-service was suspended were negligibly small compared to those observed when the tram-service was in operation.

In Dresden, also, the auxiliary test wires were insufficient to measure the potentials at the connection-points of the return conductors: Moreover, only a slight improvement over the dangerous condition at Dresden can be accomplished by adjusting the uninsulated return lines; for, even if by this means a uniform potential at all of the connection-points of the return lines is secured, the leaking of the current from the uninsulated cable to the soil and its re-entrance into the cable at suitable places cannot be prevented. The substitution of insulated lines for the uninsulated ones is the only remedy. Some insulated return conductors have recently been installed in Dresden.

4. MEASURING METHODS AND INSTRUMENTS.

There is scarcely anything new to be added in this respect to what was given in last year's report. The experiences in Strasburg and Dresden show that the methods worked out and tested in Elberfeld can be conveniently used, and that the results obtained indicate with great certainty the location of districts endangered by earth currents.

Two new large instruments were purchased during the year, viz., one recording amperemeter and one bond tester.

The recording instrument serves especially to determine the average values of the currents in the return and feeder cables. It is provided with a clockwork which can be set for different time intervals varying from six minutes to six hours, so that the variations occurring during a long period as well as the characteristic variations of the tram-service can be clearly observed. The electric part of this instrument depends, as in the case of the others, upon the principle of the Deprez-D'Arsonval instruments, i. e., the motion of the pointer is produced by a movable coil suspended in a permanent magnetic

field. This instrument can be used directly as a voltmeter, and, by the addition of shunts, as an amperemeter.

The bond tester consists of two rods for making contact, and of a very sensitive differential galvanometer which also operates on the moving coil principle. One of these contact rods is constructed as a double contact and serves to connect the galvanometer with the two ends of the rail-joint, while the second contact rod, which is also connected to the galvanometer, is moved on the rail during the measurement until the galvanometer needle is on zero. Then the drop, due to the rail-joint, in the voltage of the tramway current (or, when the service is suspended, in a current lead to the rails from an auxiliary battery) is equal to the drop in voltage of the same current in the continuous length of rail between one of the double contacts and the variable single contact rod.

Thus, the resistance of the rail-joint is not given in absolute ohms, but in terms of the resistance of the continuous rail. If the normal rail length is known, the increase in the resistance of the rail due to the joints can then be calculated directly.

5. NEW POINTS OF VIEW.

A new case of corrosion with the indications usual in Electrolysis induced the management of the Strasburg water works to call upon the Commission a second time, as already stated, and a supplementary investigation was therefore made at that place.

A four-inch water pipe which had been in the ground for about thirty years was corroded, for a length of about 500 feet, to such an extent that it was necessary to replace it with a new pipe. Since previous measurements of potential differences between the pipes and rails made at this point indicated the latter to be in a neutral zone, that is, neither a danger zone nor a protected zone, it seemed unlikely that a large amount of return current escaped from the pipe to the rails at the time the measurements were made. It was thought, therefore, either that an escape of current from the pipe into the earth, but not into the rails, had been brought about by increased resistance of pipe joints and destruction of the

protective coating, in conjunction with good conducting soil (possibly ground-water leading toward a connection-point near the central station); or else that the damage might have been done at a former time when the return circuit conditions of the road were different, so that there was possibly a danger zone at this spot.

The first assumption is supported by the fact that the surface water is relatively high at this point, so that the conductivity of the soil is increased; and several of the socket joints were actually found to be leaking. Besides this, the river Ill is in the immediate vicinity of the line and flows close by the central station, so that earth return currents would find in this way a good return path to the central station. The second assumption is supported by the fact that another pipe just as old as the damaged one and connected to it, but lying in a parallel street where there are no tracks and where similar soil exists, has not shown such corrosion. Besides, by far the largest and most numerous corrosion pit-holes were found on the side of the pipe facing the tracks, instead of being uniformly distributed around the whole pipe.

The measurements of potential and current which were repeated at this spot only confirmed, however, the previous measurements, and showed that the currents flowing through the pipe at this point, following the fluctuations of the operation of the tram system, are so small that the danger to the pipes cannot be considered to come from this cause. It is to be noted that the old four-inch main had, in the meantime, been replaced by a new six-inch one; but it is not probable that the electrical conditions were appreciably affected thereby.

This case may be considered, therefore, to represent a particular type of corrosion, and is generally important in the solution of the Electrolysis problem. Moreover, the municipal authorities were anxious to ascertain, if possible, the cause of the corrosion; so that it seemed desirable to follow up the case from the standpoint of chemistry and electro-chemistry. The questions involved can be put into the following form:

Can iron thus corroded in such soil without the action of external forces (rail return currents or the like)? If so, can

the phenomena be observed on the spot? Are there purely local actions present during the corrosion, such as electromotive forces and polarization voltages, which can be determined qualitatively without error and measured quantitatively with sufficient accuracy?

A solution of this problem requires a thorough chemical analysis of the soil, besides a practical method with proper ground contacts for determining the polarization voltages. The metallic contacts formerly used become polarized even in the ground, and, under certain circumstances, lead to fictitious results when used for the measurement of the potential of the soil. Since, however, no one appears to have used suitable electrodes, further experience must be collected. It will be also necessary to learn how iron will act electro-chemically in such solutions of salt as occur in the soil.

In making such researches the co-operation of a chemist and an electro-chemist with especial experience in this work is desirable. The preliminary experiments have already been started with the co-operation of experienced specialists.

6. FUTURE PROCEDURE.

It is intended for the present to continue the work in the same way as previously, that is, to collect further material from the electrical field, and also to pursue the study of the chemical and electro-chemical features, so as to determine all of the conditions which produce danger from corrosion. In this connection, it is proposed particularly to make experiments at several characteristic places without electric tram systems, where pipes have laid a long time in soil where chemical and electro-chemical actions may be expected.

(Signed) W. H. LINDLEY, *Chairman*,
Electrolysis Commission.

Frankfort-on-Main, May 29, 1905.

SECTION V.

SUMMARY AND CONCLUSIONS.

GENERAL SUMMARY.

In the normal operation of an electric railway using the rails for the return circuit, the current (and therefore the potential)

in the rails is increased progressively by each car that discharges into the rails. Hence, where the rails are the only return conductors, the potential therein increases both with the number of cars and with the distance from the power station; and the maximum potential difference in the rails is the drop in potential (due to the resistance of the rails) between the furthermost car on the line and the power station.

It is a popular mistake to say that electricity follows the path of least resistance. Electricity follows all paths open to it, and divides itself directly as the conductivity of the various paths. Consequently, whenever and wherever there is a difference of potential between two grounded points of a conductor, as is always the case where grounded rails convey return tramway current, some current will flow through the ground and along the pipes buried in the ground.

With the composition of soil usual in city streets, it is generally agreed that the smallest direct currents will cause electrolytic corrosion where they pass from the pipes into the ground, and an attempt is sometimes made to gauge such damage by measuring the flow of current in the pipes and ascribing a destructive effect of 20 pounds of iron or 74 pounds of lead to each ampere-year. Assuming the accuracy of this relation, it should be understood that this annual destruction of 20 or 74 pounds, respectively, per ampere of current occurs wherever the current passes from the pipe into the ground, and, as there is no limit to the number of times that the same current may leave and re-enter the pipes, there appears to be no theoretical limit to the destructive power of a single ampere of direct current. Likewise, direct currents, very much smaller than one ampere, may, in time, produce wide destruction.

Since every electric railway with uninsulated returns will produce stray currents, and since these stray currents will inevitably cause electrolytic damage to neighboring pipes and other subterranean metal wherever the current passes from the metal into the street soil, it follows that the only ways to *prevent* such electrolytic damage are:

1. To stop the use of uninsulated returns and the consequent escape of stray current, or,

2. To prevent any of the current which strays to the pipes or other metal from again entering the ground.

The first remedy (1), which is fundamental and absolute in character, is completely attained by the use of double trolleys, either underground as in New York and Washington, or overhead as in Cincinnati and the District of Columbia; or, in special cases, by effective insulation of the rails themselves. The difficulty, in this case, is that such prevention of stray currents depends solely upon the traction company, and can be enforced only in the rare event of there being effective provisions to that end in the traction franchise, or by protracted process of law. On the other hand, the second remedy (2) lies largely within the scope and power of the gas and water undertakings, and relief of this nature is, therefore, frequently attempted by connecting the street pipes with the electric circuit in various ways and places.

As this latter kind of remedy (2) has been applied upon an extraordinary scale in the City of Chicago (see pages 813 to 816), and in the City of Detroit (see pages 816 to 824), a discussion of one of these cases will cover all other and minor attempts at relief of this character :

The Chicago work was based upon the usual electrical survey, which divides the pipe system into three districts, classified as follows :

1. The large "negative" district (where stray current is flowing from the rails to the pipes), which has been considered immune ;

2. The smaller "positive" district (where the accumulated stray current is returning from the pipes to the rails), which has been considered the endangered district requiring protection ;

3. The so-called "neutral" or intermediate district, which is alternately negative or positive, according to the distribution and loading of the cars, the state of the track and rail-bonding, and the weather and soil and other conditions.

Upon the supposition that electrolytic damage is practically confined to the positive district, the most comprehensive efforts possible were made to eliminate this positive condition from the Chicago gas pipes, and to make the whole system of gas piping negative to the rails.

To this end, every pipe-joint in the positive district was thoroughly bonded with copper, and return feeders were brought from various points of the pipes to the negative bus-bar, which converted the gas piping into a better conductor than the rails themselves.

This, of course, vastly increased the current on the pipes in the former positive and intermediate districts, and correspondingly increased the flow along the pipes in the negative district.

Now, in the opinion of your Committee, the dangers and liabilities attaching to this great increase of current throughout the piping system, form a serious objection to any remedial scheme of this kind—quite apart from its obvious expense and difficulty of application and maintenance. Moreover, as a remedy for Electrolysis, this plan is founded upon an erroneous premise, viz.; that electrolytic damage is confined to pipes that are positive to the rails.

Since electricity flows along the negative and intermediate as well as the positive pipes, the latter proposition is equivalent to maintaining that no current can leave the pipes *except to return to the rails.* But it is evident, and experience has amply confirmed, that the current on the negative pipes will shunt proportionately every pipe-joint which introduces additional resistance, and will pass from one pipe or conductor to every other of lower potential—resulting eventually in electrolytic destruction at these joints and places.

In the case of negative water pipes, there is evidence that many of the joint-leaks, leading to ultimate breakage and flood, have their origin in Electrolysis; and your Committee is satisfied that the comparative absence, in the past, of external evidence of electrolytic destruction at the joints of negative gas pipes is due more to the reduced strength of the currents diffused throughout these large areas than to the negative condition of the pipes. In other words, with these small currents, the rate of destruction is proportionately reduced, and the time is correspondingly deferred when the external evidence of completed destruction will eventually assert itself.

In Chicago and in Detroit, however, the great increase of

current in the pipes, resulting from the remedial scheme, tends to create in the former intermediate and negative districts conditions which, considering the greater areas involved, may ultimately prove to be worse than the original trouble in the positive districts. In Detroit, a single 12-inch wrought iron gas pipe was found to be carrying at times a current of 3600 amperes (see Chart, page 818), and lead joints in cast iron pipes have been actually melted by the current!

Furthermore, every addition, or change in location of a power station or sub-station, and every return feeder connected with the rails, creates a new positive zone and requires a corresponding change in the pipe return circuit. Likewise, every break in a pipe- or rail-bond, and every change in the conductivity of piping or rails, will upset the return conditions.

Finally, there is manifest legal objection to any action which enormously increases the currents straying from the rails, and changes their distribution. Gas pipes are not the only tenants of the streets exposed to Electrolysis. For example, water and gas pipes and services are everywhere interlaced; and, if these water pipes, which were formerly positive to the rails only, are made still more positive to the interlaced gas piping by the bonding of the latter to the negative pole, a greatly increased current wlll pass along and from the water pipes into the gas pipes, causing proportionately greater damage to the water pipes from Electrolysis. This unauthorized use of street piping for the return electric circuit, if of damage to others, can doubtless be prohibited by law, thus nullifying the large investments to that end, apart from any question of liability for the damage caused.

Hence, it appears that a pipe return system, even when applied upon a scale so expensive as to be generally prohibitive, affords but temporary and uncertain relief in the positive district, and greatly increases the danger from Electrolysis in the negative and intermediate areas, especially at the joints of the pipes.

Continuous lead cable sheaths, which are of small and homogeneous section with high and *uniform* resistance, have been connected to the negative bus-bars with apparently satisfactory results, as far as the protection of the lead itself is concerned;

but your Committee entertains no hope of preventing electrolytic damage to heterogeneous networks of street piping by any so-called protective method which encourages an increased flow of stray currents to and along the pipes. On the contrary, your Committee is convinced that the only practical way of preventing Electrolysis of street piping is to prevent the escape of stray currents by the use of a completely insulated circuit.

This is the logical solution of the Electrolysis problem, and the natural way to secure this result is by proper stipulations in the traction franchise. Such stipulations, however, cannot be readily interpolated into existing franchises; hence, legal action must be generally relied upon to prevent the discharge of a destructive agent into the streets.

While little encouragement can be drawn from the Peoria (pages 769 to 787) and Dayton (pages 789 to 792) litigation, it should be remembered that the *demonstrable* damage caused by Electrolysis is accumulating continuously, while the ineffectiveness of the various protective measures is being continually demonstrated; thus, the legal aspect of the problem grows always stronger, and must soon become overwhelming.

Of the various plans for *mitigating* electrolytic destruction, your Committee endorses only those which aim to reduce the stray currents by decreasing the maximum difference of potential between two points of the return rails, and by increasing the resistance between the rails and the pipes. The British Regulations, although utterly insufficient in character and degree, are directed toward this end; and it is this general method which the German Commission are testing. It may be here noted, however, that foreign conclusions must be applied with caution to the unique conditions existing in American cities, where electric traction is now practically the sole means of local transit and is used upon a scale and under a pressure of traffic generally unknown in foreign countries.

The proper application of this ameliorating method requires the thorough and permanent bonding of all rail-joints and cross-bonding of both rails and tracks at frequent intervals, and also such construction of the rail-foundations and roadbed as will increase as much as practicable the resistance between the rails and the ground. Then the rail network

must be divided into suitable sections by separate return feeders, which sections of rails and return feeders should be so proportioned or regulated that the potentials at the return connection-points are practically equalized.

Parenthetically, the German Commission are not always quite clear in their reasons for equalizing these potentials. *Given a fixed limit to the difference of potential in the rails*, there appears to be no reason why inequality of potentials at the connection-points should seriously increase the electrolytic damage; it might have even the opposite effect. But, on the other hand, it is absolutely essential to an efficient tramway service *at the minimum potential difference* in the rails that these potentials at the return connections be practically equalized; otherwise, the effective potential difference in certain sections of the track will be reduced below this minimum working limit, and the service thereby disorganized.

The return connection-points, if thus equalized, are virtually sub-stations, which divide the rail network so that the maximum difference of potential in the whole system is the maximum drop in any one section. The more numerous these connections and the shorter the sections, the less, manifestly, becomes the maximum potential difference in the rails, and, other things being equal, the consequent escape of stray current. Hence if these divisional conductors be multiplied indefinitely, and if the potential equilibrium of the various sections be continuously maintained by proper adjustment, the difference of potential and consequent straying of current may be reduced to such a degree that electrolytic damage will become practically negligible.

But, instead of trying to carry this purely mitigating system to the ultimate and impossible limit of prevention, it is obviously preferable to destroy the root and branch of the whole Electrolysis evil by using an insulated (return) circuit.

In this connection, it will be remarked that the German Electrolysis Commission has not once referred to the desirability or possibility of confining the tramway current to a completely insulated circuit, thereby *preventing stray currents*. They have, on the contrary, devoted themselves exclusively to the *mitigation* of electrolytic destruction, by formulating all

kinds of ways and means for reducing the strength of the stray currents.

Yet, notwithstanding the great expense and difficulty of applying and maintaining their exhaustive precautionary Regulations (pages 893 to 899), they find it necessary to supplement these comprehensive measures by recommending (Rule 3) that the present maximum permissible potential difference in the network of rails be limited to *one volt!*

In other words, an effective method of minimizing the stray currents is so elaborate, and at the same time so restricted, that a single insulated circuit seems preferable, even on the score of simplicity and cost — without regard to the all-important fact that the German Regulations merely *mitigate* an evil, which the insulated circuit *completely eliminates*.

Your Committee, therefore, feels that German experience does not yet shed any encouraging light upon electrolytic conditions, but, on the contrary, that it tends to emphasize the advantages of the double trolley system.

It is also worth noting that, while the reasonable use of return feeders will greatly reduce the potential difference in the rails, it tends to multiply the number of endangered areas by creating a positive zone about each return connection. Moreover, although the quantity of stray current is dependent upon the difference of potential in the rails, it by no means depends solely upon this difference; the conductivity of the soil and of the materials in and tenanting the soil exerts an equal influence.

Your Committee disapproves of the indiscriminate use of insulated pipe-joints in the hope of preventing a flow of electricity along the pipes. In some places, this plan will prove useful; but, without proper selection and precaution, it is likely to do more harm than good, inasmuch as the reduced pipe current must leave and re-enter the pipe at each insulated joint, thereby multiplying its destructive effect. It follows that electrolytic damage to any system of street piping may be considerably influenced by the kind of pipe-joint adopted—whether lead, cement, machined or gasket.

Finally, it should be remembered that the underground piping and other metal employed in the larger cities not only

represent original investments of great magnitude, but, apart from the danger to life and property attaching to any escape of gas or flood of water (or conflagration in default of water), the repair and renewal of these pipes and metal are made far more costly by modern street pavements and traffic—not to speak of the loss and inconvenience caused to modern communities by the continual disruption of streets and sidewalks.

CONCLUSIONS.

In view of the state of the art of electric traction, as set forth in the foregoing pages, your Committee unanimously concludes:

First: Electric railways should be held responsible, by the terms of their franchise, for all damage to others engaged in the discharge of franchise obligations or in any lawful pursuit or occupation, caused by their overt failure to control their own currents.

Second: The immunity of street piping and other metal in centres of population from electrolytic damage due to stray currents demands that electric railways shall employ in such districts completely insulated metallic circuits for all currents; and such railways may be especially exempted by Ordinance from responsibility regarding Electrolysis *so long as they effectively maintain such circuits.*

Third: In small communities where local conditions are favorable, or wherever the property liable to electrolytic damage is of minor value, the rails may be used for the return current, *subject to Clause First*, PROVIDED:

(1) The potential difference in the rails be sufficiently* reduced by properly balanced return feeders and thorough bonding.

(2) The rail-foundations be constructed to increase as much as practicable the resistance between the rails and earth; and

(3) There be proper supervision to insure conformance with these requirements.

*Your Committee cannot indicate suitable local voltages, but it has been seen that the German Commission commend a present maximum potential difference of *one volt*.

Fourth: In rural districts, or wherever no property is liable to electrolytic corrosion, the uninsulated rails may be used *per se* for the return current.

Respectfully submitted,

A. G. GLASGOW, *Chairman*,
JOHN WILLIAMSON,
S. P. CURTIS,
ARTHUR H. HALL,
Committee on Electrolysis.

PROF. ALBERT F. GANZ, M. E.,
Consulting Electrical Engineer to the Committee.

April 10, 1906.

THE PRESIDENT: Gentlemen, are there any remarks?

MR. MILLER: If Mr. Brownell is present, it may be interesting to hear what he has to say about this report.

THE PRESIDENT: It is stated, Mr. Miller, that he has left the city. Are there any further remarks?

MR. A. S. MILLER: Mr. Chairman, as is well known, there is a very radical difference of opinion as to the best method of handling the currents on gas mains. I am very much interested in the subject, and hope I will hear something from some of the people present who are of the same opinion as the writers of that report on Electrolysis. A great deal has been said about the bad effect of taking the return current from the pipes by wires, but nothing has been offered us in its place. I stand here as the champion, or rather as the representative, of those who have tried to make the best of a bad job by taking the current from the pipes by wires after it has gotten on. While, in a measure, I am in accord with the members of this committee in the view that it is not a good practice, but, so far as I can find out, it is a great deal better than to leave the current on. I would like very much to hear from some of the members of the Institute whose ideas are different from mine. I would like to know why they have the currents on the pipe and let them find their way off, when, as a matter of fact, we all know that you cannot keep the current off the pipe in the beginning. As I understand the substance of the report,

it is that you ought not to let the current get on the pipe. I quite agree that we ought not to allow it to get on the pipe, and the question has been, of course, how to prevent that. I have yet to find out how we can keep it from the pipe.

MR. EGNER: I would like to ask Mr. Miller how he deals with the current to keep it off the pipe with wire.

MR. D. MCDONALD: Mr. President, I would like to ask if any of the members of this Institute have tried the plan of suing the electric railway company for the damage done to the gas pipes. This is a subject in which I am vitally interested, and I want all the information I can get. I do not want to bring an injunction if it is not going to amount to anything, and I am not going to sue them for damage done to service pipes unless I know pretty well where I stand. I would like to know if any of the members that have had trouble of this kind have succeeded in making the railways pay for it. If they have, and that could be made generally known, I believe that that would be one of the best means for stopping this trouble with electrolysis.

THE PRESIDENT: Mr. Egner asks for information as to the method which Mr. Miller has used.

MR. A. S. MILLER: Mr. President, we found that there were certain centers in our territory where there was a decided difference in the voltage between our pipes and the tracks, and at this point we attached our mains, and the water mains and underground cables to copper returns, which in turn were carried back to the negative side, or the ground side of the rotaries of the electric railway company. The railway company has worked with us, has furnished copper returns, and has been entirely reasonable and fair with us in everything that we have asked them to do. The result has been that we believe we have substantially stopped the electrolysis in the sections where we are connected up in that way without increasing the difference in the voltage between our pipes and the railway tracks at any other point. By connecting in the water mains and underground cables we are carrying such a small amount of current on our pipe that it is almost impossible to measure

the drop around the joints or on any short length of pipe, including the joint. I would like to know what disadvantage there is in that method.

MR. WALTON FORSTALL: Mr. President, as bearing upon the point that Mr. Miller has just described as to the action of the trolley company in Baltimore, it might be interesting for me to state here, that in Philadelphia some examples of the effect of electrolysis were brought to the attention of the trolley company, and we presented a bill to the trolley people for the damage, and they apparently were very glad to settle it. The attitude that they seemed to take was, that it is a disgrace to a trolley company if they allow their current to escape, and they were willing to pay the bill. It may be said that the roadway construction there is of the very best. In other words, their rails are of very large section, well bonded and in many cases encased in concrete. In addition, about every three or four hundred feet, a copper wire is bonded to the rail, run into a manhole and returned through a conduit system to the power house. So that there is very little chance for the current to escape to the mains. On about 1,300 miles of mains we have had only one or two cases which afforded us any ground for complaint.

MR. D. MCDONALD: Mr. Chairman, I am very much obliged indeed to Mr. Forstall for that statement. In the town where I am located the electric railway company denies it is their current. They say that it may come from the telephone, and it may come from lightning, and that it is for me to prove it is their current. I think the attitude of the company which Mr. Forstall has just described is very progressive, and when all the railway companies take that attitude the difficulties of the gas people with electrolysis will be pretty largely done away with, but as long as our mains are used for the passage of the return electric current, and as long as the railway companies continue to have their own way about it, the result will continue to be that we will have trouble one way or the other, and the people that make the trouble are the ones that ought to pay for it.

THE PRESIDENT: I would like to hear an answer to Mr.

Miller's inquiry as to whether the method he described is not a correct method. I would like to know something about that myself.

MR. STONE: Mr. Chairman, while I was not going to answer Mr. Miller exactly, I was going to say that we have been troubled somewhat by electrolysis, and I was a little bit in doubt about the best method of handling it. I had an examination made of the property by two experts, or by two gentlemen who thought they were experts in that line, and one gave an entirely opposite opinion to the other as to the proper way to handle it. One of them said to bond the pipe, and the other one said to insulate the pipe. I am just as far ahead now as I was before I asked them what to do. I think anyone who looks into the subject will find themselves in just that position. There does not seem to be any hard and fast rule laid down as yet to be pursued in this matter.

In regard to what Mr. McDonald has said, I think it is all right to send a bill to the traction company for the damage, provided you know who to send the bill to, but when you have two or three interurban companies operating in a town together with the local company, and each one of them says it is the current from the other company that is making the trouble it is pretty hard to prove it is not.

THE PRESIDENT: What did you finally do?

MR. STONE: We finally insulated the pipe, and we have had very good success. At least we have got the amount of electricity that we are carrying down to a point where I think we will have very little trouble. We have had no success at all in making any of the traction companies admit that it was their current which was damaging the pipe. They all fought shy. In a case where two or three companies are operating in a town, and especially where the power is supplied from different stations, there are different times in the day when you will get the current from one company, and at some other times of the day you will get the current from the other company. It is a hard proposition.

Mr. G. S. Carson: Mr. President, in regard to Mr. Miller's statement as to putting in copper returns from the gas pipe to the street railway station, I would like to ask if, as a matter of fact, it would not act as a path for any surplus current that might come over the wire. In other words, if there was resistance build up at any point on the rails, the current would take the easier path, and come by the gas pipe and water pipe around through the copper wire for a part of the distance. The fact that there was no difference in voltage would not seem to me to be positive proof that there was no current flowing. I would like to ask some electrician here who has made that a study if that would not be the fact.

Mr. A. S. Miller: It is quite true that if there is an increased resistance along the rails, there will more current flow through the pipe, and connections of that kind should be made with great caution, and should be very frequently inspected. The connections that we have made are made so that we can put ammeters on to the line, or rather onto the return wires at frequent intervals, and test the amount of current flowing. That is done every few weeks. We test the current to see whether the railway company is keeping up its part of the agreement. We have found at times that the bonds get broken. Our apparatus is arranged with switches, so that in case the current gets too heavy at any time we can open up the switch and therefore increase the resistance on our line.

Mr. D. McDonald: Mr. President, if I may speak on the subject again, I should like to say that I have read very carefully the report prepared by the Committee of the American Gas Light Association in regard to the prevention of electrolysis, and I feel, as I think a great many gas men are coming to feel, that it is decidedly bad policy on the part of gas companies, as a general thing, to allow the impression to get out that they have got to take care of the electric current, or that it is their business to take care of any part of the electric current coming from a street railway system. There is a tendency among all of the electrical

engineers, apparently, to make it appear that the street railway's part is fulfilled when they generate the current, and that the matter of taking care of it afterwards is something with which they have no concern, and that it can go out and do anything it wants to. We have sat still and allowed it to damage our pipes, and have said nothing at all about it. I feel that we are not bound to go to them on our knees and ask what we shall do. We have got no satisfaction so far, and I think we ought to force a test case of some kind and press it to a final conclusion in our highest courts, so as to enable us to protect ourselves. I do not think it is up to us to go to expense to take care of the current coming from electric lines. It is up to the street railway companies to take care of what they generate.

THE PRESIDENT: Is there any further discussion on this subject?

MR. EGNER: Mr. President, I merely wish to say that I was very glad indeed to hear that a gas man like Mr. Miller has adopted the system which he described. I proposed it more than ten years ago, and I am still talking about it. Ten or twelve years ago I investigated and was impressed with the advantages of that system.

MR. MILLER: If I may have the last say, Mr. President, I had that in use twelve years ago in Oil City.

MR. EGNER: Well, I do not know about the date to a certainty, but that is a plan which I have been recommending for a long time.

MR. McDONALD: I have had it in use for about five years, and during that time I have become satisfied that you simply transfer the location of the trouble and do not get rid of it.

MR. STILLSON: I would like to see this discussion carried a little further. I would like to know what success has been met with from the use of insulated pipe or insulated couplings, that will prevent the current from flowing on our services. If there is something that can be done in that line, would like to hear what results have been obtained from anybody who has

tried them. After hearing them, would like to state the result of some tests which I made.

The President: Gentlemen, Mr. Stillson wants to know what success insulated couplings have met with, and has some more remarks to make after his question is answered. Can anyone enlighten him on insulated couplings? Somebody in the room must certainly have used insulated couplings.

Mr. Stone: Mr. President, I do not like to talk too much about this subject. I have used them, and so far as I know they seem to work all right. They reduced the amount of current on the line to a minimum. While the couplings have not been on for a long time or for a length of time sufficient to tell definitely just what the result will be, from what tests we have made since we put the couplings on they seem to show that they will answer the purpose and do the work.

Mr. Morton: I should like to ask Mr. Stone how far apart he puts the insulated couplers. It seems to me that the distance between would have a considerable effect upon their efficiency.

Mr. Stone: We have one line that is laid with the ordinary coupling joints, and it has no electric current at all. On the line that we insulated we put them in every four or five hundred feet.

Mr. Goodnow: Mr. President, we have had some experience in this line. On a part of our high pressure distribution system we had to combat this trouble. We have had occasion to renew portion of a line about thirteen miles long, and as a means of prevention we have put in about three miles of six inch enameled pipe. This is just about completed, and the object was, of course, to insulate the pipe from the current traveling in the ground. We expect this to prevent the current getting on the pipe, and therefore not being obliged to leave it. We also, at another point further down, have put in insulated joints in enamel pipe in connection with a patent coupler. Previous to insulating it we found a very large amount of current traveling on this pipe. The trolley tracks in the vicinity were in very bad condition. They were improved, however, and also changed from single to double

track, which, of course, made a much better condition of affairs, and with the introduction of these joints in the line there has been a desrease of current in some instances if from 80% to 90%. This state of affairs has been going on for about six years. We are awaiting results from what we call enamel pipe, which is pipe enameled and baked twice on the outside; what result we will get from that can only be told by continued use, and we hope to know more about it in a year or two.

MR. D. MCDONALD: Mr. President, I move that it is the sense of the members of this association, based on experience, that nothing that the gas company can do will protect our underground pipe system from destruction by electrolysis so long as the street railway companies use the earth for the return of its current. I would like to offer that as a resolution, so that we may go upon record as taking action in regard to this matter.

THE PRESIDENT: There is a motion before the house, Mr. McDonald. That would be out of order, I think, at this time.

MR. D. MCDONALD: Then I will withdraw it for the present. Any testimony that we can give will aid us at some future time, and if we can protect ourselves it is our legal duty to do so. I would like to see some action started.

MR. VON MAUR: Mr. Chairman, there are about fifty miles of high-pressure wrought-iron pipe around St. Louis, and it is all equipped with insulating couplings placed every three hundred feet. This pipe has been in the ground for a period of eighteen months, and, thus far, no trouble has been experienced from electrolysis. Where the pipes pass under street railway tracks, several insulating joints are placed between the lengths on both sides of the track, and at least one length of pipe is boxed in and surrounded with pitch. There was one case where the insulating joints were omitted on either side of the track, and that pipe was very badly eaten out.

I do not think we can say anything final on insulating joints as yet, but the above has been our experience to date.

We expect to make an electrolytic survey in the near future.

MR. WITHERBY: Mr. Chairman, there is no question which affects the gas industry more than this question of the effect upon underground mains by electrolytic current. The gas company was in the field first in almost every case. The electric railway companies have come in secondarily. It seems to me fair that the man who was on the ground first should have the best right, and there is no reason why the gas companies' mains should be used as a return feeder, or that they should be used as wires, whichever way you may wish to term it, for the purpose of bringing the current back to the trolley company's power house. The trolley companies should be made to put in the return feeders themselves that will be capable of carrying the return current. If they will only do that, which they can do very readily, it will take care of most of the trouble, or at least 95% of it. They fight it on the ground that it is expensive. Copper does cost money. And they refuse, in a great many cases, to even co-operate with the gas or water company, and they will probably continue to do it until they are forced to define their position or are threatened with heavy damages. Some of the trolley companies have been co-operating with the gas and water companies, and have removed the trouble so far as it is possible to do so, but in other cases they have absolutely refused to do anything; have absolutely declined to have anything to do with it. I think that this association ought to go on record, and if it cannot be done in any other way, then we ought to bring a court proceeding and make a united effort at some one point where our position will be fairly safe, and make a test case, and force it through until the courts of the United States make a decision.

MR. RICE: Mr. President, I am very glad to hear these remarks on the legal side of this question. I will say no more on that side of it except to say that I endorse the sentiments which have just been expressed very heartily. I think that the attention of this Institute should be directed very strongly to the Peoria case, the first case mentioned in the report of the Committee on Electrolysis. I had the privilege of talking recently with one of the attorneys in that case. The report

of the master in chancery was favorable at all points to the position of the water company. Of course, the water company would stand in the same relation as the gas company would in such a matter. The trial judge, Judge Grosscup, however, removed this case from the master in chancery, which, I understand was a very unusual proceeding in such a case. He removed it on the ground that he wished to hear more testimony. This was in 1901. Five years have passed by without a decision. Petition after petition has been sent up to this judge asking him to reach a decision in the case. One of the gentlemen here has spoken about a test case being brought. Here is a test case. Here is a case which raises all the points which should be brought out. They are brought out well in this case. It seems to me we might do something towards lending our influence, either severally or jointly, towards bringing this particular case to a conclusion. The conclusions of the master were favorable, and eventually it would seem as if the conclusions of the judge must be favorable also.

Mr. Witherby: Mr. Chairman, this is not a thing, as I view it, that we ought to leave in any sort of an unfinished condition. We ought to be sure of our rights and then take a stand one way or the other. There are lots of small gas companies today that are losing thousands of dollars annually because of the trouble they are having with electrolysis. Many of them, perhaps, have not come to a full realization of the extent of the damage which escaping electricity is doing to their services, and may not, until they find their entire system is broken down. They find stray appearances of it once in a while, or may find sections of pipe which they have to replace. They take it out and put it away possibly as a witness for some future time. It lies around for about a year and then it is thrown into the waste pile. There are some of the more extensive systems where the damage from this source has become so serious that negotiations are now pending between the street railway system and the gas company as to a final settlement of the difficulty. I think this Institute ought to come to the front and place itself in a position which cannot be misunderstood.

Mr. Graf: I would like to inquire if any gentlemen can tell me what would be the increased cost in the trolley construction in order to provide a proper return feeder? We know about what it costs us to return this current on our mains. What would be the increased cost to the trolley company per mile of track? What percentage would it be? Would it be five, ten or fifteen per cent.? If we can get it in percentage, we can get it down to dollars and cents.

The President: Can anybody answer Mr. Graf's question?

Mr. Witherby: Mr. President, I heard the question, but I do not know I can give the exact figures. It is entirely a question of the amount of current that the trolley company is using and the amount of feeders they already have in position. I know of one case where the gas company and the railway company looked over the situation in some way, and I think it was found that the trolley company would have to expend, in order to put in the amount of feeder wire that was necessary, something like one hundred thousand dollars. Nothing came of it. It was a matter of indifference to them how the current got back, whether it used the gas company's mains or the water company's mains, they were not going to be put to the expense of putting in copper to stop it. As to the actual percentage, it would be hard to state it. The same size of feeder wires would carry a return current for most any size of pipe. It would protect a four-inch line or a thirty-inch line, and so you can hardly use that as a basis of comparison. The existing condition in any particular locality that must be met must be looked into carefully and properly worked out. I think the more up-to-date railroad systems of the country today are placing pretty nearly the proper amount of copper that is required, but on the small trolley roads in the smaller places, and on some of the interurban lines, they pay little or no attention to the matter, and do not seem to care very much what damage they inflict on the other fellow.

Mr. Summers: Is it not true that some of the trolley companies have been carrying on experiments along their lines so as to get at data for making the feeders effective? I think

I have heard of that. In fact, I know of one company which established an experiment of that kind, but how successful it was I do not know, or how extensively the experiment was carried on.

The President: That is done, I believe. I do not know with what measure of success.

Mr. Witherby: The cast iron connection has been abandoned by all the companies that have tried it, and the proper bonding of the rails has been the most important thing tried to take care of it. The electric welding process has not been satisfactory on account of expansion, and the companies which are at all up to date are now universally using copper wire.

The President: Is there anything further, gentlemen? Did Mr. Stillson want to make any further remarks?

Mr. Stillson: Mr. President, I wished to give you what data I had obtained. The idea was to determine whether we were preventing the flow of electricity over the service. We used a standard short coupling with rubber gaskets on one section of the test; on the other a special insulating coupling. There are really three conditions in the test.

1. No resistance as on plain pipe.
2. Resistance of short coupling.
3. Resistance of insulating coupling.

The pipe itself has no resistance.

The short couplings with rubber gaskets had .06 ohms resistance in the experiment which we made.

The special insulated coupling, which was supposed to be an insulator, had 1.75 ohms resistance. In either one of these cases the amount of current that passed would be considerable, and would cause considerable damage. You can very easily get the drop of potential between your main and the rail, and knowing the ohmic resistance, calculate the amount of current passing from the rail to the main, or vice versa.

We attempted, in the above experiment, to get natural conditions, as the couplings tested were buried some six weeks or two months before being tested. Soil about test No. 2,

gravel and loam; about test No. 3, gravel. Points of contact in test being about four feet apart.

MR. WILLIAMSON: Mr. President, I do not see any reason why the electric companies should not take care of their leakage. Most of the gas companies I think take the ground that the electric companies ought to take care of their leakage just the same as we take care of the leakage on our mains. It does not make any difference whether they want to take care of it or not, or whether it is going to cause them expense. They can take care of it, and it does not make any difference what it costs. They ought to be made to take care of it.

MR. ANDREWS: The question was brought up a few moments ago as to whether the cast joint of street railway lines was effective. In the city of Duluth where the temperature varies anywhere from ninety above to forty below, that type of joint is used with perfect satisfaction. They have been used for the last five years, and we have no trouble from electrolysis so far as we can observe.

THE PRESIDENT: The motion was that the report be accepted and the committee continued. All in favor of the motion as stated will signify by saying "Aye." Contrary minds. It is carried.

MR. D. McDONALD: Mr. President, now I wish to renew the motion which was ruled out of order a few moments ago, that it is the sense of the members of this association, based on experience, that when the under-ground pipes become paths for the electric currents of street railways, the pipes will be damaged and in many cases destroyed, and that there is no way of laying such pipes or protecting them by coating which will prevent such destruction.

Now gentlemen, I make this simply for the purpose of putting this Institute of men who have an opportunity to know about this, on record as saying that while they may to some extent obviate this difficulty they cannot prevent it, and so far as we can determine this question the courts will be influenced very largely, I think, by the evidence of so many

men who have had an opportunity to know just what the effect of electrolysis has been. I think we ought to go on record as expressing the opinion of the men who know, so far as we can obtain it, so that the burden may be placed on the men who have created the trouble.

Motion seconded.

THE PRESIDENT: Gentlemen, you hear the motion made by Mr. McDonald. I will not attempt to repeat it. Are there any further remarks?

MR. RICHARDS: I want to say that the street railway companies alone are responsible for the trouble. They are the ones that should be made to settle. They alone are responsible in every direction and in every particular for the harm and the danger and the expense which the gas companies have been put to. When we run a main through a street and have a leak in that main, and an explosion occurs, the gas company alone is responsible. Why should it not be the same way with the electric companies who allow this dangerous element to escape from their wires? There are means by which the current can be controlled, and we ought to go upon record unitedly in placing the blame where it belongs, and that is upon the trolley companies and not upon the gas companies.

THE PRESIDENT: Any further remarks, gentlemen, on this motion? All in favor of the motion as stated will signify by saying "Aye." Contrary minds, "No." The motion is carried.

The next is the

REPORT OF COMMITTEE ON NEXT PLACE OF MEETING.

Mr. Witherby, is your Committee ready to report?

MR. WITHERBY: *Mr. President and Gentlemen of the Institute*: Your Committee on place of next meeting have found it an impossible task to try to suit every one. The last two meetings were held in western cities, Milwaukee and Chicago, and naturally the East comes in next. Now that we

have grown to such a healthy, sturdy crowd, ordinary hotel accommodations are going to be taxed to find a place where we can all be taken care of in a fairly good way. After looking the situation over carefully, your Committee have decided unanimously in favor of Washington, D. C. (Applause.)

THE PRESIDENT: Gentlemen, you have heard the report of the Committee on the place of the next meeting. What is your pleasure?

MR. RAMSDELL: Move it be adopted.

Motion seconded.

MR. EGNER: Mr. President, I am not interested to the extent of one cent whether the Institute comes to Norfolk next year or not, but I was commissioned by the Jamestown Exposition, who, as you know, are going to hold a great exposition in Norfolk next year, to invite the Institute to come there. We have a very large building, expressly erected for just such occasions, on the exposition grounds. There are two very large halls in it, both of them larger than this room here, and with any quantity of committee rooms—seventeen in all, I believe—and with all other usual accommodations. I was authorized to offer them all to the Institute free of cost. I now do not believe you will come, but as your Committee did not see fit to make mention of this courteous invitation, gentlemen, I just wanted to tell you that you were heartily invited to do so. I think, however, this invitation should not have been by-passed without some acknowledgment. I will see you all at Washington, and I hope when you get as far as Washington that some of you will come down to Norfolk and see the great show, which, in some ways, will be the best that has ever happened in this country, and especially from a military and naval point of view, as the greatest armies and navies of the world have promised to be represented upon this occasion. Norfolk is a small place compared with New York, Chicago or St. Louis, but I am sure you will not regret your visit to this fast becoming metropolis of the South. There are a great many points of interest to be seen aside from the attractions of the exposition, mainly in the historical line;

for remember, gentlemen, Anglo Saxon civilization in America started at Jamestown, Virginia, which is the event we are about to celebrate at Norfolk next year. Next year England, Germany, France, and even Austria, Italy, Japan, and other countries have all promised to send soldiers and warships there, and if you come you will see a great show, such—I believe it no exaggeration—as has never been equaled at any exposition of modern times in this world. You will all be well taken care of. They are building hotels there now to beat all. They are building a great hotel on the grounds, to be known as the "Inside Inn," similar to the one at the St. Louis Fair two years ago. If you meet in Washington, I shall have the pleasure of seeing you there, I hope, and let me say again that I hope as many of you as can will come over to Norfolk, which is not far from Washington after all, and when you get there just call on me, and I will show you around.

THE PRESIDENT: Any further debate? All in favor of adopting the report of the Committee will signify by saying "Aye." Contrary minds, "No." It is carried.

MR. CLARK: Mr. President, has the time for the next meeting been fixed?

THE PRESIDENT: I think it has been fixed by the Constitution. I think it is fixed as the third Wednesday in October.

Is Mr. Learned in the room? If so, we will hear his paper.

Mr. Charles A. Learned, of Meriden, Conn., then read the following paper on

THE RELATION OF THE COMMERCIAL GAS MAN TO THE INDUSTRY.[1]

First Section—By Mr. Charles A. Learned, Gas Engineer and Manager.

Second Section—By Mr. John C. D. Clark, Commercial Gas Man.

Third Section—By Mr. Richard H. Thomas, Manufacturer of Gas Appliances.

[1] A composite paper presented by the National Commercial Gas Association for the American Gas Institute Convention.

Section the First.

The commercial man of the gas industry has taken such great strides to the fore in the last few years that he now stands forth a prominent factor in the promotion of gas output, and as such is entitled to, and should receive, some decided recognition from the industry.

In a brief way, I would like to outline what, in my estimation, are some of his just claims for consideration by the gas fraternity.

As a business builder, I believe, with many other gas men, that he has been largely instrumental in promoting gas sales along lines which, in the ordinary course of business, the gas engineer and gas manager would not have been likely to discover.

He has been the means of distributing gas through industrial appliances and various other channels which had not been exploited before his coming into the field. He has judiciously spent much time, money and energy in devising, promoting and marketing gas-using appliances for domestic and industrial purposes, which up to his advent the gas producer perhaps never thought of.

He opened a new field in the matter of advertising, for gas men, who before his coming never thought of advertising their product, and advertising today enters largely into the promotion of the industry.

The large factor which this branch of the industry has become can only be realized by one who keeps continually in touch with this end of the business, and who watches the thousand and one ingenious methods employed.

If we are willing to concede that the commercial man has taken the initiative in this step toward giving the industry a new impetus, if he has been, as we must all admit he has, a valuable factor in helping to keep gas in active and successful competition with the electric light and others of its rivals, then the industry should make acknowledgment to him for his work by entering into hearty co-operation with him.

There are in my mind a number of ways in which we can work with the commercial gas man to our mutual benefit. For

instance, many of the troubles of the maker, seller, buyer and user of gas appliances arise from the fact that these appliances are not standardized. Many misrepresentations are made either knowingly, or unknowingly, which bring about dissatisfaction to all, and prove a positive detriment to the industry. The selling of gas appliances under such conditions can bring about but one result, the destroying of confidence and good will of the consumer or user, and the hampering of the gas output.

We are all familiar with the numerous complaints that come and the incidental cost of remedying them where appliances of inferior construction are sold, and where the estimated cost of operating them is placed far too low, by reason of which we are swamped with high bill complaints, and the dissatisfied consumer does much toward killing the sale of other appliances.

Now the manufacturer and seller, as well as the buyer, should be set straight by some authorized body, who could intelligently gauge the worth of his appliances, tell him what would be considered standard and advise him from the technical viewpoint how best to attain this standard. This would be one step in acknowledgment of his worth as a factor in the industry.

Again, in the matter of exhibits. From the nature of his wares he cannot carry samples with him to show prospective buyers. The gas company man and the engineer are of course largely interested in seeing the newest and best types of appliances, and it would be greatly to their advantage if they could see the various ranges, water heaters, etc., in some exhibition hall, where at one time they could examine and compare their style, make up, etc., and advise with the maker and seller as to their efficiencies and the claims made for them. This holds good also in the matter of lighting devices, lamps for indoor and outdoor use, arc system lighting, etc., and such an exhibition would give the lamp man a chance to put his goods before his prospective buyers in an attractive and advantageous way. The engineer can hardly be expected to do anything toward getting appliances together or giving such an exhibition. That is the manufacturers' or sellers' work, but inasmuch as any advance made by the appliance man in

the quality and efficiency of his output must be reflected in the gas sales, the commercial man should receive the earnest encouragement and hearty support of the gas maker in this kind of an undertaking.

In this day of specializing in order to keep to the front it is necessary to employ trained men in their particular lines. Take the line mentioned before; the advertising, for instance. This is an art in itself. The specialist in the advertising line knows what to advise in the using of mediums, how to build up attractive texts, cards, booklets, pictures, etc., and how to circulate them. A knowledge of this particular branch of the industry would hardly be within the province of the gas engineer to acquire.

The manufacture of appliances is a vast industry. Months of patient and persistent work are put upon designing, drawing and pattern making, and other detail work, incidental to the making of an appliance ready for the market. Large sums of money are spent in producing appliances the sale of which for some unforeseen reason is difficult or unprofitable. Expensive and laborious work is carried on continuously, looking to the improvement of efficiencies, and modifications of forms to meet up-to-date ideas, all of which is important, not only to the advertiser but to the seller, buyer and user.

The interests of the gas appliance manufacturer are so closely allied and interwoven with those of the manufacturing gas man and the gas manager that they are practically one, with the manufacturer's position well to the fore. In the last few years he has made a place for himself as a promoter of gas sales which commands the attention of the entire gas fraternity, and the more marked his work becomes the more closely is the engineer tied down to his particular field of making and distributing gas.

The engineer's time must be so largely taken up with solving the problems of bettering his product and reducing his costs, having so active a competitor in the field as the electric man, that he is likely to keep too busy to attend much personally to the gas sales proposition.

The manufacturer and his agents are in a position not only to help build up the gas sales, but they actually do a large

amount of missionary work. They go about searching for new fields in which gas can be used as fuel. These in their own interests they bring to the notice of the gas men visited, and perhaps bring to their attention appliances of which the non-traveling gas man has been entirely uninformed.

The use of gas as a fuel is now in its infancy and, with the energy that is being put into it by the energetic manufacturer and commercial man, is bound to show wonderful results. There is one other important thing for the gas man to consider when sizing up the worth of the manufacturer and the commercial gas man to the industry, and that is, whereas the gas appliance manufacturer must be satisfied with his first and only profit, the appliance he puts into the gas man's hands will be a continual source of revenue and profit to the gas company.

The gas commercial man and gas appliance manufacturers have recently organized an association in which it is intended that all shall be active members.

Its object, like that of other associations, is the interchanging of ideas and promoting business along right commercial lines, and as naturally the manufacturer of gas appliances cannot enlarge his business without increasing the business of the gas man, it would seem to me that he is entitled to the gas man's most hearty support and co-operation.

Section the Second.

It would seem to me that there is considerable room for a National Commercial Gas Association, or work by the Institute along the same lines. If the Association work is good for the engineering branch of our business, it seems to me that the commercial end should have an association also.

The very best thing that I have ever gotten out of association work has been the meeting of men from all parts of the country and obtaining from them their experience for the past year, the different plans they have tried and the results obtained therefrom. It is an old saying that the experience of others is the cheapest that one can get, inasmuch as it costs nothing, and may be the means of preventing one from wasting considerable money.

Gas companies are being forced to sell their product for less money than formerly, while engineering science has not developed ways to produce gas materially cheaper. It is, therefore, very essential that gas appliances should be brought up to high efficiency; that there should be practically no cost added to the appliances for maintenance. In operation they should be fool proof, and the operators of appliances should be thoroughly instructed so as to obtain the very best results and the highest fuel economy. In this way great numbers can be induced to use gas and to continue its use; therefore, a commercial body should be maintained, in which we could confer with the manufacturers and obtain most efficient appliances. It is the proper step.

I think that the whole subject might be summed up under the head of "Appliances; their cost, their maintenance and the education of the users and the gas company employes."

Under the head of appliances there is no question but that they should be standardized. If there were such a thing as a standard range it would enable each manufacturer to build in accordance therewith, and the efficiency of operation of each such appliance would then have to come up to a certain mark before it would be considered "standard."

As to economy of construction, if these appliances were standardized it would be possible to use economy along all lines. For instance:

Cost.—The cost to manufacture appliances would be reduced; the cost to the gas company for maintenance and repairs would be reduced, as would also be the cost to the consumer.

Maintenance.—This is a point that many companies overlook when placing gas appliances on their lines. It looks to me as though, where companies are proposing to place or are placing large numbers of appliances on their lines, that the maintenance or future cost to them is the thing to be considered instead of the first cost. It is not a fair proposition to a customer to place in his hands a stove that is going to cost excessive money to maintain; neither is it fair for a manufacturer to sell either party an appliance that is going to be a source of expense for maintenance.

It is becoming quite general throughout the country for gas

companies to clean and adjust gas ranges, and in some cases their maintenance service goes further, and the different parts are supplied. Standardizing of the range would in such cases be an especial saving to the gas company.

Education.—Under this heading there is quite a field for good work to be done for the customers of the company. Gas company employees also need educating. There is no question that, if everybody were properly educated in the use of gas for fuel purposes, the business would make gigantic strides at once.

How many cases does one find where the gas company has placed appliances in a customer's premises that, had the salesman and customer both been educated in the use of gas for fuel, they would have installed an entirely different set of appliances.

To me the whole thing sums up about as follows: If association work is good for the engineering branch of the gas business (as I believe it has been acknowledged that it is) there is no question but that it would be the best step that was ever taken to have the commercial men form an association, or have the work carried on through other channels.

Gas companies are continually spending money for working improvements, main renewals, service repairs, laying larger mains, etc., all of which must come to naught unless there is a corresponding output or sale of gas. It is acknowledged by all that if the people knew as much about gas as some of the gas men do, they would all *use* it for all domestic and largely for industrial purposes. The expense at all times is largely regulated by the class of appliances. It is, therefore, time that gas companies should see that their customers are not being continually fooled by fakirs, and that all appliances placed on the market should bring out the very best there is in their gas, and that the appliance should not be a source of endless expense to the consumer and to the gas company.

This perhaps can be best attained by bringing the gas man and the appliance manufacturer into the closest possible touch for consultation, and upon the convention floor as enjoying equal privileges in discussion, etc. The best makers of

appliances could and would then join heart and soul with the gas man to stamp out the fakir and his wares.

In conclusion, I would say that the work of the commercial association should commence where the work of the past association stopped, and that it should be our business to keep in touch with the manufacturers of appliances; thus to see that they turn out the proper sort of appliances at the proper time, make necessary improvements and alterations as needed, educate selling organizations to a knowledge of the business, and educate the consumer so that he can obtain the very best results.

Section the Third.

The true strength of a manufacturing concern lies quite as much in the loyalty and helpful encouragement of its customers as in its experience and the size of its bank account. No industry has succeeded that did not build upon "co-operation" as one of the foundation stones, and the progressive man is bound to be a firm believer in its power. In an association, co-operation of its members is necessary to secure the best results. In a manufacturing industry, team work among the employees, all pulling for a common end, is vital to its success.

Going beyond the factory, co-operation of customer with manufacturers means much to the latter. A manufacturer's customers are an invaluable asset from the standpoint of information alone. Using the ideas of both parties—namely, the man who sells and the man who manufactures—means the production of a piece of goods that will stand the test of criticism from all quarters, and co-operation is the force which makes the results possible.

In the gas industry co-operation has reached an especially high plane in the formation of the American Gas Institute. Each of the organizations forming the new body had been doing effective work in its particular field, but progressive members believed better and more lasting results would follow consolidation, and the new organization stands as a powerful illustration of the fact that co-operation spells success.

In what relation does the appliance manufacturer stand to

the new body as it represents this gas body? Except socially he is barred from sharing in the benefits of the magnificent organization, because topics affecting the commercial end of the business (and these are the only ones in which he is particularly interested) are rarely discussed, unless the order of business in the new body differs radically from that of, for illustration, the American Gas Association, and because he can have no voice in asking questions or entering into discussions for the purpose of bringing out points of value (when understood) alike to the gas man and appliance maker.

The maximum good in association membership to the manufacturer can only be secured when, as a member, First: He stands on an equal footing with the other members. Second: When he can meet them in debate on the floor of the convention. Third: When, by being an active member, he has all privileges of the organization, and in consequence has a strong incentive in working for its up-building. Fourth: When he knows that papers or talks bearing on the production and sale of gas appliances will occupy all of the time except that required for business.

The National Commercial Gas Association opened to the manufacturer a new and valuable channel for information to reach him. If this means is continued in much the same way it will unquestionably prove of incalculable benefit to him. Its value lies in the fact that it concerns itself exclusively with matters affecting the commercial end of the gas industry. The plan gives to the manufacturer an opportunity of meeting those men in the industry who buy of him or whom he hopes to persuade to buy of him, and to discuss with them on the floor of the convention ways and means for improvements, new appliances of various kinds, and other items that are to the interest and concern of both parties.

Collectively, as an association of commercial men and gas appliance manufacturers, they co-operate to better conditions, and experience has proven that the closer the manufacturer can get to his customer, and vice versa, the better are the results. One of the objects of the National Commercial Gas Association that appealed to me (it may be found in its Constitution) is as follows: "The encouragement of manufacturers

to produce high grade and highly efficient devices that require gas for light, heat and power."

Such a form of organization in our judgment is precisely what the gas appliance manufacturer has been looking for for years. It is simply a body of men banded together, pledged to encourage and help him in the production of his goods and he, in turn, stands pledged to the other members to devise ways and means for improving present appliances by producing appliances of a higher grade, equipped with highly effective devices that shall burn gas as a fuel.

In this organization, as you probably know, the Commercial Association to which I have referred, the manufacturer stands on a par with every other man connected with the body; and he receives the maximum amount of benefit from it, because he is admitted to participation in its affairs as an active member. The meeting with active members of a gas association in a social way, and the manufacturer has heretofore been unable to go farther than this, is certainly extremely pleasant, but the results are in no wise as beneficial to either party as discussion of topics on the convention floor, in which both the gas man and gas appliance manufacturer take part. The gas man sells the appliance to the consumer, knows his own needs and can suggest same to manufacturers of appliances at the convention, where all may hear and take active part in debating the question.

If the American Gas Institute proposes to devote a day or two of its convention to a discussion of matters concerning the commercial end of the industry, there is perhaps no need for an independent organization; but believing that the marketing of a product is equally as essential to the success of an industry as the production of the same, it appears to me that greater recognition is due the commercial topics than has heretofore been given them.

If the American Gas Institute is to devote the time of the convention, or the largest share of it to a discussion of engineering topics, and treats only superficially those concerning strictly the commercial end, and furthermore, does not admit the manufacturer to active membership, then there is certainly room for a body like the National Commercial Gas Association,

and such an organization is bound to receive the hearty support of every manufacturer of gas appliances, and at least, in time, the same support by gas managers, because both are vitally concerned in the outcome of any and all discussions that may take place at its meeting.

DISCUSSION.

THE PRESIDENT: Gentlemen, this paper is before you for discussion. What is your pleasure? Is there nothing to offer on this paper?

MR. SEARLE: Mr. President, it seems to me that there were some very good points brought out by this paper. On page 7 I notice it says, "Educate selling organizations to a knowledge of the business."

To show the necessity of educating the selling organizations, I had a salesmen of one of the large water heater manufacturers arrange to meet a lot of our employes. Before he did that, I told him I wanted him to come to my room and tell me about it before he talked to them. He did so, and I asked him to explain the workings of it to me. He started in by saying, "We will assume that the water is going into this heater at thirty degrees." I said, "We will not assume anything of the kind," and I had to stop and educate that man before he started. Now that man sells heaters direct to the consumers and with good results, so that it looks as if we could afford to give some of our time to educating the selling force.

A MEMBER: How did you educate him?

MR. SEARLE: Well, I educated him all right. (Laughter.) I started in on the line that we did not get more heat from a blue flame than from a yellow flame if combustion was complete in each case, and I tried to impress it upon him that he should thoroughly understand what actually took place in the heater before he went before them, and that water at 30 deg. was ice. I took a couple of Gas Engineers' text-books, and spent about an hour or more with him to get him started right. I cannot state exactly what I said, but he certainly needed a lot of education.

A MEMBER: It seems to me, Mr. President, that the time is coming when the biggest thing we will have on our hands in some places will be to meet the competition we will have from electric appliances. I think on that ground we ought to form a good relationship between the manufacturers of appliances and our sales departments, and adopt the best business methods for placing the appliances using gas before the public, and then work on the line of making them cheaply and making a lot of them. We ought to be able to sell them. That seems to me the wisest feature of the business. We can work on the manufacturer for some time, but we need to establish better relations, and we need a good deal of assistance to learn how to sell the appliances, especially when we are meeting with a five cent. per kilowatt hour rate in the electric light line.

MR. W. H. GARDINER, JR.: Mr. Chairman, I would like to say a word on this subject. The gas business today seems to have entirely outgrown the idea that we have got any monopoly. The whole thing is based upon the footing purely of a commercial undertaking supplying artificial light, heat and power, and in that we have got many competitors. Now the business, it seems to me, is divided into three big groups. The physical department, the commercial department, and the financial or corporation department. I think that the commercial department is a very important one. When we take it in any other form of manufacturing what is it that worries the manufacturer? Is it his means of making his goods or is it his means of disposing of the goods after he makes them? To my mind it is the latter. That is really the important thing on which he spends his best ability at times, and he uses every effort to organize his selling force to be effective, and finds markets to absorb his product. I think, therefore, we should give the closest attention to this question of commercial activity in the gas business. It is the one means, as it seems to me, whereby the gas business can retain that position in supplying the demand of communities for artificial lighting, heat and power to which it is entitled.

MR. CLABAUGH: It seems to me that this is one of the

most important papers which has been read at this meeting, for the reason that the American Gas Institute has now had the way pointed out by which it can co-operate with the commercial organization and take up this question with the manufacturers of these appliances. Here is an organization which has been formed that can do this work, and can co-operate with the American Gas Institute as well, if not better than any other. This organization is formed for the purpose or advancing the gas interests, and is formed to co-operate with the gas industry, and assist in its development in every way possible.

In days gone by the engineering department did not think the commercial department of the industry worthy of consideration. The engineering department would be of very little value if the commercial department did not sell the product, it is the commercial department that comes in contact with the consumer for the benefit of all connected with the industry. It is through that department that the sales are made, and by the co-operation of the engineering and commercial departments you then have what every business should have, a complete and satisfactory working plant. Therefore, I say that the Institute should co-operate with this commercial organization in every way it possibly can, and encourage it to go on with the work which it has begun in order that the commercial association manufacturers and commercial men may come together. The manufacturer has his place upon the floor, and the place of the commercial man is at his right hand. There should be better co-operation between the two branches of the industry. The commercial branch can certainly bring up some ideas and bring something to the engineering branch that will be of benefit to the engineering industry, and certainly better feeling and results can be obtained. (Applause.)

THE PRESIDENT: I think, Mr. Clabaugh, that it is the intention to have this co-operation take place in the new order of things, and that is why this paper has been secured from the National Commercial Gas Men's Association.

Is there anything further?

Mr. Persons: Mr. President, I move that a vote of thanks be extended to Mr. Learned and to the Commercial Gas Association for this paper which has just been read.

Motion seconded.

The President: It is moved and seconded, gentlemen, that the paper be accepted and that a vote of thanks be extended to the several authors. Are there any remarks? All in favor of accepting the paper and extending a vote of thanks will say "Aye." Contrary minds "No." It is a vote and the motion is carried.

Now Mr. Forstall, you had something to bring to the attention of the Institute.

Mr. Walton Forstall: At the 1905 meeting of the American Gas Light Association a new standard for cast iron pipe and special castings was adopted, and in the proceedings of the meeting were published a set of thirty-four plates containing the leading dimensions and the weights of all the castings embraced by the standard. The design, and therefore the leading dimensions of the castings had been carefully considered and represented the ideas of many large users. The minor dimensions and the weights were worked out by people whom it was reasonable to suppose could be depended on for accurate work. Unfortunately, there was not much time available for the work, and soon after the adoption of the standard, it became apparent that many errors in calculation had been made, and that, although these errors did not affect leading dimensions at all, nor even weights to any appreciable extent, yet before working drawings could be made from the data adopted, a thorough revision of all previous calculations would be necessary. This revision has been made, and a revised set of plates has been prepared, which to all intents and purposes are identical with those adopted by the American Gas Light Association. As the standard was hurriedly adopted by the Association, due to the lack of time for discussion, it is recommended that criticisms from members of the Institute be asked, blue prints being sent to all members desiring them; these criticisms to be sent to whatever committee may be appointed for the consideration of such matters,

and that such committee present the plates revised as they may deem advisable, to the next meeting of the Institute for adoption as its standard.

It is desired to bear testimony here to the work of Mr. James G. Davis, of the Philadelphia Gas Works, for the time and care he has given to the task of revision.

I move that the incoming President appoint a committee to receive any criticisms which may be sent in of the revised standard for cast iron pipe, the idea being that this committee will present to the American Gas Institute at its next meeting such a standard as the Institute will adopt.

Motion seconded.

THE PRESIDENT: Gentlemen, you have heard the motion. Are there any remarks? If not, all in favor of the motion will please express it by saying "Aye." Contrary minds, "No." The motion is carried.

MR. A. S. MILLER: Mr. Chairman, will that committee send out to the members of the Institute this proposed standard in advance? At the last meeting of the American Gas Light Association this was put through in a very hurried way, and without the members having much chance to see it.

THE PRESIDENT: I presume that it will be done.

MR. WALTON FORSTALL: I would just like to say that it does not seem advisable to send out to all of the members of the Institute the thirty-four plates containing the dimensions, etc., but the idea was that any member who was interested in it, upon making application, could get a set of the blue prints at any time after the first of next month. The idea is that any man who wants to criticize, will have the opportunity to get the blue prints, and then that the criticism will be considered by the committee.

MR. PERSONS: I just want to make an announcement. There are no tickets for the dinner tonight. Those who desire to attend will please present themselves at the main dining-room on the ninth floor of this hotel. There are a few gentlemen who have sent word of their intention to take tickets, or

who have asked for reservation of seats, and I would be glad to see those gentlemen as soon as possible.

THE PRESIDENT: Is Mr. Olds in the room? If not, I will ask the Secretary to read his report on the Information Bureau.

Secretary Dunbar read the following report:

REPORT OF THE BUREAU OF INFORMATION OF THE OHIO GAS LIGHT ASSOCIATION TO THE AMERICAN GAS INSTITUTE. MEETING OCTOBER, 1906.

Since the last meeting of the Ohio Gas Light Association in March of this year, when it was voted to amalgamate with the American and Western Associations to form the American Gas Institute, there have been but few inquiries made of the Bureau of Information.

I attribute this largely to the diversion of attention attendant upon the changes being inaugurated.

In the two previous years of its existence the interest was marked, and the Bureau answered a very considerable number of questions.

The nature of the inquiries that have been answered indicate that this department might be made to fill a most useful purpose and that it would occupy a distinct field, not encroaching upon nor conflicting with that of any other department. Its usefulness, particularly to the smaller companies, may be made very great.

It has the advantage over the Question Box that it is always ready to receive and refer questions for immediate answer, and through that fact can deal with inquiries that cannot await the annual meetings.

I would recommend that the Bureau be continued by the Institute and organized with a Chairman and five committee members representing Manufacture, Residuals, Distribution, High Pressure, Supply and Mercantile or Sales Departments. All inquiries to be addressed to the Chairman, and the questions involved to be by him allotted to the proper committee member, the latter to refer them to such members as he may believe able to assist, to compile the replies and submit them to the

Chairman for answer to the questioner. At each annual meeting the Chairman to submit a report embodying such of the questions as might prove of general interest, and the replies of the Bureau thereon.

Under such organization the only person aware of the identity of the questioner would be the Chairman of the Bureau Committee; the questions asked would be of an immediately practical character, and, together with a discussion of the Annual Report, should record the best thought existent on any given problem or method.

Respectfully,

H. L. OLDS, *Chairman.*

THE PRESIDENT: What is to be done with this report, gentlemen?

MR. RAMSDELL: I move that it be received and spread upon the minutes.

Motion seconded.

THE PRESIDENT: Gentlemen, it is moved that this report be received and spread upon the minutes. Are there any remarks? All in favor of the motion stated will signify by saying "Aye." Contrary minds, "No." It is carried.

MR. T. D. MILLER: Mr. President and Gentlemen: The committee that was appointed at the Western meeting last spring in regard to working out a definite and suitable formula which would express in a single statement the value of the gas with reference to its calorific value and candle power has done some work since that May meeting, but they have not been able to arrive at any definite conclusion. Differences of opinion exist throughout the committee, and we have concluded that they are due entirely to the fact that our data is not extensive enough as yet to enable us to get down to a basis. Therefore, this report is submitted more in the nature of a report of progress. It is for the members of the Institute to say whether they want that committee as a committee on this subject continued. The work is going on anyhow. If it is continued in the name of the Institute, the committee is going to ask for information so that we can get a

lot of data together from all over the country relative to all kinds of oil and all kinds of fuel as a basis on which to complete the formula, if possible.

THE PRESIDENT: Gentlemen, what is to be done with this report? I think it would be a good thing to continue the committee.

MR. SUMMERS: Mr. President, I move the report be received and the committee continued.

Motion seconded.

THE PRESIDENT: Gentlemen, are there any remarks? It is moved and seconded that the report be received and the committee continued. All in favor of the motion say "Aye." Contrary minds, "No." It is carried.

Gentlemen, that completes the program. If there is anything you have to offer we will be glad to hear it at this time.

A MEMBER: Mr. President, do I understand that if we adjourn now, the program having been completed, that we are to have no session tomorrow? Is this a final adjournment?

THE PRESIDENT: I think that the adjournment of the convention better be held up until tomorrow so as to see what, if anything, turns up. I mean final adjournment.

MR. MILLER: I move we adjourn.

Motion seconded and passed.

NOTE. On Friday, October 19th, no session of the institute was held, and the adjournment as above taken became final.

APPENDIX.

REPORT TREASURER OHIO GAS LIGHT ASSOCIATION.

DELAWARE, OHIO, November 20, 1906.

To the Amalgamation Committee,
Ohio Gas Light Association.

GENTLEMEN: I have the honor to present herewith the financial report of the Ohio Gas Light Association for the period between March 21, 1906 and November 20, 1906.

Receipts.

Balance on hand March 21st	$ 508.52	
Received from dues	1,536.00	
Received from initiations	210.00	
Received from advertisements,	1,525.00	
Received from gas journals for report of twenty-second annual meeting	214.70	
Total		$3,994.22

Expenditures.

Printing and stationery	$2,312.80	
Postage	30.00	
Expense reporting twenty-second annual meeting	214.70	
Secretary's salary, one year	750.00	
Secretary's salary, seven months	437.50	
Telegrams and telephone tolls	6.05	
Express	7.76	
Expense Amalgamation Committee	54.50	
Balance on hand as per certified check	180.91	
Total		$3,994.22

Badges on hand this date, ten.

Respectfully submitted,

T. C. JONES,
Secretary and Treasurer.

REPORT TREASURER WESTERN GAS ASSOCIATION, MARCH 18, 1907.

Receipts.

Repayment Loan American Gas Institute.	$ 900.00	
Received from F. H. Shelton, Chairman Exhibit Western Gas Association, St. Louis	473.70	
Sale of proceedings	36.50	
Sale of badges (10)	35.00	
Central Passenger Association	17.00	
Dues	2,520.00	
Membership fees	260.00	
Balance May 1, 1906	1,134.68	
Total		$5,376.88

Disbursements.

Postage and telegrams	$ 121.81
Invitations to 29th annual meeting	78.30
Printing papers for 29th annual meeting	463.00
Printing Mr. Gardiner's paper 29th annual meeting	186.10
Electrotypes and engravings 29th annual meeting	101.70
Sundry printing and stationery	102.75
Balance paid for printing volume containing proceedings for years 1903-4-5 and express charges	1,043.68
Passenger associations	5.50
Expense Cleveland meeting	104.13
W. H. Tolman for lecture	140.70
Expressage, freight and telegrams	35.91
Insurance on library and proceedings	27.50
Salary Secretary-Treasurer from May 1, 1905, to May 1, 1906	400.00
Salary Secretary-Treasurer from May 1, 1906, to November 1, 1906	200.00
Loaned American Gas Institute	900.00
Expense K. M. Mitchell, president	28.00

Dues returned, account overpaid	$ 5.00	
Gas educational fund	100.00	
Publishing proceedings 1906............	1,211.10	
Box Rent...............................	4.00	
Balance cash on hand...................	117.70	
Total		$5,376.88

Badges on hand, 74.
Volume of proceedings, 560.
Thompson Memorial Library, volumes and treatises, 216.
One book case.

James W. Dunbar,
Treasurer.

REPORT TREASURER AMERICAN GAS LIGHT ASSOCIATION, YEAR ENDING SEPT. 30, 1906.

Receipts.

Dues for year 1902	$ 5.00		
Dues for year 1903	5.00		
Dues for year 1904	45.00		
Dues for year 1905	138.00		
Dues for year 1906	4,108.00		
Dues for year 1907	30.00		$4,331.00
Initiation fee, members elected 10-19-05		$ 980.00	
Initiation fee, members to be elected 10-19-06		20.00	
Sale of proceedings		383.85	
Sale of association badges		15.00	
Sale of uniform accounts		225.00	
Sale of blue prints		324.04	
Sale of reports on electrolysis		15.83	
Sale of Journal of Gas Lighting		.60	
Refund, deposit for railroad agent		17.00	
Interest on deposit		65.68	2,047.00
			$6,378.00
Cash balance from last year,			
Permanent fund		250.47	
Current fund		1,228.95	1,479.42
			$7,857.42

Expenditures.

Expense of 33d annual meeting	$ 159.90	
Reporting 33d annual meeting	215.17	
Expense of committee of arrangements, 33d annual meeting	139.70	
Expense of May council meeting	39.70	
Reporting May council meeting	33.50	
Publishing proceedings, Vol. XXII	1,950.90	
Distribution of published proceedings	186.87	
Printing advance copies of papers	290.05	

Mailing advance copies of papers........	43.75	
Subscription to trustees' gas educational fund..............................	250.00	
Salary of secretary and treasurer........	750.00	
Clerical assistance....................	250.00	
Subscription to publications	12.00	
Miscellaneous printing, circulars, etc.....	150.70	
Postage stamps and stamped envelopes...	144.68	
Stationery..........................	31.45	
Telegrams..........................	4.74	
Expressage	7.37	
Office expenses......................	2.80	
Books for library.....................	6.00	
Bank Collection.....................	4.61	
Lecture, B. H. Meyer, 33d annual meeting	100.00	
Advertising.........................	19.00	
Blue prints, standards of C. I. specials...	155.07	
Journal of Gas Lighting...............	.55	
Expense of publishing and mailing reports of committee on electrolysis....	500.22	
Insurance	26.06	
Expense of Chicago meeting of Committee on American Gas Institute	38.75	
Association badges	110.00	$5,514.54
Balance,		
Permanent fund........... 250.47		
Current fund............. 2,092.41		2,342.88
		$7,857.42

Treasurer's Supplementary Report to October 15, 1906.

Receipts.

Dues for year 1905	$ 5.00	
Dues for year 1906	5.00	$10.00
Sale of Proceedings	8.50	
Sale of Reports on Electrolysis	.75	9.25
Cash Balance October 1, 1906,		
Permanent fund	250.47	
Current fund	2,092.41	2,342.88
		$2,362.13

Expenditures.

Stationery	$ 1.00	
Flowers for funeral of Vice-President	10.00	$11.00
Cash balance,		
Permanent fund	250.47	
Current fund	2,100.66	2,351.13
		$2,362.13

Geo. G. Ramsdell,
Treasurer.

At the time above report was issued it was estimated that the unpaid account and expenses amounted to approximately $350.00; a supplementary report will be made at time of transfer.

UNITED STATES PATENTS RELATING TO GAS.

ISSUED FROM OCTOBER 1, 1905, TO SEPTEMBER 30, 1906.

October 3.

800,659. **Gas or Gasoline Engine.** Ernest H. Korsmeyer, Rosedale, Kans. Filed July 20, 1903, Serial No. 166,274.

800,708. **Gas Burner for Furnaces.** John C. Beckfeld, Pittsburg, Pa. Filed Dec. 27, 1900. Serial No. 41,231.

800,770. **Gas Engine.** Alfred Steinbart, Carlstadt, N. J. Filed Feb. 20, 1904. Serial No. 194,514.

801,025. **Gas Stove Attachment.** S. Leibenglick, New York, N. Y. Filed Dec. 15, 1904. Serial No. 236,928.

801,061. **Acetylene Gas Generator.** Edwin A. Chamberlin, Los Angeles, Cal. Filed Nov. 23, 1904. Serial No. 233,967.

October 10.

801,241. **Gas Fixture Safety Device.** Philip Hochheimer, Newark, N. J. Filed March 10, 1904. Serial No. 197,456.

801,242. **Gas Burner Safety Attachment.** Philip Hochheimer, Newark, N. J. Filed Feb. 9, 1905. Serial No. 244,830.

801,314. **Acetylene Gas Generator.** Albert H. Graves, Chicago, Ill. Filed Jan. 11, 1904. Serial No. 188,620.

801,473. **Means for Attaching Supply Tubes to Gas Fixtures.** Carter H. Page, Jr., Philadelphia, Pa., Assignor to the United Gas Improvement Co., Philadelphia, Pa. A corporation of Pennsylvania. Filed June 17, 1903. Serial No. 161,871.

801,268. **Gas Retort Closing Device.** Robert Reister, Dessau, Germany, assignor to Dessauer Vertikal-Ofen-Gesellschaft, M. B. H. Berlin, Germany. Filed Aug. 8, 1904. Serial No. 219,983.

801,456. **Inverted Gas Light Incandescent Lamp.** Heinrich W. Hellman and Oskar Arendt, Berlin, Germany. Assignors to Gesellschaft fur Hangendes Gasgluhlicht, M. B. H., Berlin, Germany. A corporation. Filed Oct. 27, 1903. Serial No. 178,803.

801,492. **Gas Retort Charring Machine.** John West, South Port, England. Filed Nov. 13, 1903. Serial No. 181,027.

801,533. Incandescent Gas Lamp of the Inverted Type. Wilhelm Maaske, Berlin, Germany, assignor by mesne assignments to Franz Glinicke, Berlin, Germany. Filed Aug. 18, 1904. Serial No. 221,283.

801,618. Incandescent Gas Light. Charles Scott-Snell, Westminster, London, England, assignor to Air Light Co., Limited, Westminster, London, England. Filed Dec. 29, 1904. Serial No. 238,865.

October 17.

802,218. Incandescent Gas Burner. Thomas F. Kent, Jersey City, N. J. Filed Aug. 20, 1904. Serial No. 221,468.

October 24.

802,380. Gas System Safety Device. George H. Emerson, Robert D. Hawkins and Frederick T. Kitchen, St. Paul, Minn. Filed Dec. 30, 1904. Serial No. 238,959.

802,833. Acetylene Gas Generator. Martin Thayer and Jonathan E. Reynolds, Wareham, Mass. Filed Oct. 12, 1904. Serial No. 228,148.

802,904. Ammonia Gas Condenser. Alvin H. Baer, Waynesboro, Pa. Filed Aug. 1, 1904. Serial No. 219,043.

802,931. Gas Producer. Jerome R. Georgem, Worcester, Mass., assignor to Morgan Construction Co., Worcester, Mass. A corporation of Massachusetts. Original application filed July 10, 1903. Serial No. 164,934. Divided and this application filed Aug. 3, 1904. Serial No. 219,357.

October 31.

802,986. Incandescent Gas Lamp. Adam J. Hofmann, Newark, N. J. Filed March 11, 1905. Serial No. 249,537.

803,068. Gas Purifying Apparatus. Pierce Plantinga, Cleveland, O. Filed Sept. 26, 1904. Serial No. 225,933.

803,078. Gasolene Engine. Henry E. Thompson, Chicago, Ill. Filed Feb. 8, 1905. Serial No. 244,769.

803,139. Gas Purifier. Bernhard A. Sinn and Frederick H. Wagner, Baltimore, Md. Filed Feb. 5, 1904. Serial No. 192,074.

803,154. Gas Condenser. John S. DeHart, Jr., East Orange, N. J., assignor to Isbell-Porter Co., Newark, N. J. A corporation of New York. Filed Dec. 21, 1904. Serial No. 237,813.

803,260. Gas Compressor. Frederick Wittenmeier, Chicago, Ill., assignor to Kroeschell Bros. Ice Machine Co., Chicago, Ill. A corporation of Illinois. Filed Oct. 18, 1904. Serial No. 228, 925.

803,444. Gas Generator. Bernhard A. Sinn and Frederick H. Wagner, Baltimore, Md. Filed Feb. 5, 1904. Serial No. 192,073.

803,449. Needle Gas Check. William S. Stapley, Bridgeport, Conn., assignor to The Bridgeport Brass Company, Bridgeport, Conn. A corporation of Connecticut. Filed Aug. 7, 1905. Serial No. 272,988.

803,490. Gas Mixer or Apparatus for Regulating the Quality of Gas. Clarence M. Kemp and Charles E. Kemp, Baltimore, Md. Said Charles E. Kemp assignor to said Clarence M. Kemp. Filed March 17, 1905. Serial No. 250,533.

803,534. Process of and Apparatus for Producing Combustible Gas Mixtures. Charles K. Harding, Chicago, Ill. Filed Dec. 6, 1904. Serial No. 235,734.

November 7.

803,557. Generating Gas. Chas. H. Claudel, Argenteuil,, France, assignor to Compagnie du Carburateur Claudel, Paris, France. Filed May 25, 1903. Serial No. 153,632.

803,617. Acetylene Gas Apparatus. Frank N. Moore, Westfield, Mass. Filed May 20, 1904. Serial No. 208,871.

803,771. Incandescent Gas Burner. James Mallol, Birmingham, England. Filed Dec. 29, 1904. Serial No. 238,807.

803,835. Incandescent Gas Mantle. Charles M. Lingren, Bayonne, N. J., assignor to The Safety Car Heating and Lighting Co., New York, N. Y. A corporation of New Jersey. Filed Aug. 12, 1904. Serial No. 220,476.

803,837. Gas Light. Thomas Maguire, New York, N. Y., assignor to Star Lamp Co., New York, N. Y. Filed July 5, 1904. Serial No. 215,234.

803,884. Lamp. Robert M. Dixon, East Orange, N. J., assignor to Safety Car Heating & Lighting Co., New York., N. Y. A corporation of New Jersey. Filed June 15, 1903. Serial No. 161,464.

803,915. Preparing Incandescent Gas Mantles. Charles M. Lingren, Bayonne, N. J., assignor to Safety Car Lighting & Heating Co., New York, N. Y. A corporation of New Jersey. Filed Aug. 12, 1904. Serial No. 220,475.

803,999. Acetylene Gas Generator. James W. Featherstone, Barker, N. Y., assignor to Alfred Featherstone, New York, N. Y. Filed Nov. 21, 1904. Serial No. 233,550.

804,025. Gas Engine Carburetor. Ogden Minton, New York, N. Y. Filed June 29, 1904. Serial No. 214,616.

November 14.

804,332. **Gas Engine.** Charles J. Moody and Victor E. Moody, Elgin, Ill. Filed Sept. 3, 1904. Serial No. 223,234.

804,441. **Apparatus for the Manufacture of Generator Gas.** Peter Stiens, Rotterdam, Netherlands. Filed Sept. 1, 1904. Serial No. 222,923.

804,409. **Incandescent Gas Burner.** Montford Kay, Clapford, England. Filed Dec. 13, 1904. Serial No. 236,656.

804,465. **Gas Meter.** Emil Haas, Mainz, Germany. Filed June 27, 1902. Serial No. 113,456.

804,464. **Gas Meter.** Emil Haas, Mainz, Germany. Filed June 27, 1902. Serial No. 113,457.

804,505. **Gas Reversing Valve.** Herman E. Schild, Monterey, Mexico, assignor to James B. Ladd and David Baker, Philadelphia, Pa. Filed Nov. 10, 1904. Serial No. 232,080.

804,509. **Automatic Gas Burner Attachment.** Solomon H. Ury, San Leandro, Cal. Filed March 6, 1905. Serial No. 248,521.

804,591. **Gas Generator.** Clarence M. Ferguson, administrator of Andrew J. Ferguson, deceased, Fort Worth, Texas, assignor by mesne assignments to American Acetylene Gas Light Co., Fort Worth, Texas. A corporation. Filed June 20, 1904. Serial No. 213,305.

804,677. **Gas Purifier.** Axel Sahlin, London, England. Filed May 9, 1905. Serial No. 259,605.

804,683. **Gas Stove.** Johanna J. Strain, Christchurch, New Zealand. Filed Sept. 27, 1904. Serial No. 226,174.

804,737. **Generating Gas.** Edward Krenz, St. Louis, Mo. Filed July 23, 1904. Serial No. 217,772.

804,814. **Gas Producer.** Edward Krenz, St. Louis, Mo. Original application filed July 23, 1904. Serial No. 217,772. Divided and this application filed Dec. 10, 1904. Serial No. 236,333.

November 21.

805,079. **Gas Economizer and Purifier.** Franz G. Koehler and Louis F. Koehler, Philadelphia, Pa. Filed Aug. 22, 1905. Serial No. 275,322.

805,086. **Acetylene Gas Generator.** Eugene Moreau, New York, N. Y. Filed June 25, 1901. Serial No. 65,920.

805,091. **Acetylene Gas Machine.** Jefferson F. Philpott, Windsor, Cal. Filed May 19, 1905. Serial No. 261,256.

805,125. Means for Automatically Shutting Off Gas Supply. Frank English, Boulder, Colo., assignor of one tenth to Wylie G. Wilson, Denver, Colo. Filed Dec. 16, 1904. Serial No. 237,166.

805,146. Automatic Regulating Gas Burner. Geo. W. Lord, Chicago, Ill., assignor to the Diamond Valve Co., Chicago, Ill. A corporation of South Dakota. Filed March 25, 1905. Serial No. 252,008.

805,235. Producer Gas Furnace. Paul Schmidt & Adolph Desgraz, Hanover, Germany. Filed March 15, 1906. Serial No. 250,277.

805,295. Apparatus for Preventing the Escape of Gas from Generators. Justus Hofmann, Witkowitzm, Austria-Hungary. Filed Aug. 14, 1905. Serial No. 274,152.

805,325. Machine for Treating Impregnated Fabrics to Produce Incandescent Gas Mantles. Joseph T. Robin, New York, N. Y. Filed Aug. 23, 1901. Serial No. 72,994.

805,396. Gas Pressure Regulator. John W. Weeks, Providence, R. I. Filed May 19, 1905...Serial No. 261,114.

November 28.

805,489. Gas Retort Bench. Silas B. Russell, St. Louis, Mo., assignor to Parker-Russell Mining and Mfg. Co., St. Louis, Mo. A corporation of Missouri. Filed May 22, 1905. Serial No. 261,537.

805,574. Electric Gas Lighter. Joseph Mlada, Manitowoc, Wis. Filed March 21, 1905. Serial No. 251,311.

805,637. Gas Lamp. Thomas Craig, Philadelphia, Pa., and Wm. S. McLewee, Yardley, Pa., assignors to the McLewee Gas Lamp Mfg. Co. A corporation of New Jersey. Filed Nov. 15, 1904. Serial No. 232,800.

805,653. Apparatus for Cleaning Manufactured Gases. Leon P. Lowe, San Francisco, Cal. Filed March 10, 1902. Serial No. 97,592.

805,654. Sight-cock for Gas Valves. Leon P. Lowe, San Francisco, Cal. Filed June 17, 1903. Serial No. 161,791.

805,658. Bunsen Burner for Lighting and Heating Purposes. Julius Moeller, Westminster, London, England. Filed Aug. 1, 1904. Serial No. 219,091.

805,911. Holder or Head for Incandescent Gas Mantles. Hugo Heidorn, Hamburg, Germany. Filed Aug. 6, 1903. Serial No. 168,444.

805,929. **Gas Washer.** Benjamin J. Mullen, Leetonia, O. Filed March 8, 1905. Serial No. 248,983.

805,985. **Gas Purifier.** Mathias F. McNelly, Chicago, Ill. Filed Oct. 6, 1904. Serial No. 227,370.

806,087. **Acetylene Gas Generator.** Henry Symonds, Long Beach, Cal., assignor by direct and mesne assignments to Superior Light & Heating Co., Los Angeles, Cal. A corporation of California. Filed Sept. 6, 1904. Serial No. 224,775.

December 5.

806,199. **Gas Engine.** Peter Schwehm, Reisholz, Germany Filed Dec. 31, 1902. Serial 137,373.

806,224. **Incandescent Gas Burner.** Oscar Weiderhold, Jersey City, N. J. Filed June 27, 1904. Serial No. 214,249.

806,305. **Gas Fixture Attachment.** Geo. P. Swift, Chicago, Ill. Filed Nov. 28, 1904. Serial No. 234,493.

806,308. **Gasoline Engine.** Rollin H. White, Cleveland, O., assignor to the White Sewing Machine Co., Cleveland, O., a corporation of Ohio. Filed Dec. 3, 1900. Serial No. 38,408.

806,428. **Inverted Lamp.** Carl Reiss, Berlin, Germany. Filed Feb. 2, 1905. Serial No. 243,885.

806,473. **Automatic Gas Regulator.** Don H. Kent, Urbana, O., assignor by direct and mesne assignments to The American Automatic Light Co., Urbana, O., a corporation of Ohio. Filed June 29, 1905. Serial No. 267,502.

806,474. **Automatic Gas Regulator.** Don H. Kent, Urbana, O., assignor by direct and mesne assignments to The American Automatic Light Co., Urbana, O., a corporation of Ohio. Filed April 3, 1905. Serial No. 253,607.

806,366. **Automatic Gas Cut-off.** Ralph H. Reiter, West Bridgewater Pa. Filed Jan. 4, 1905. Serial No. 239,610.

806,610. **Gas Engine.** Joseph Williams, Jr., Pittsburg, Pa. Filed April 23, 1904. Serial No. 204,559.

806,722. **Prepayment Meter.** James J. Wood, Fort Wayne, Ind. Filed Dec. 3, 1904. Serial No. 235,412.

December 12.

807,071. **Gas Producer.** Bruno Graupl, Cologne-Deutz, Germany. Filed Sept. 14, 1904. Serial No. 224,442.

807,033. **Gas Holder Tank.** August Klonne, Dortmund, Germany. Filed Jan. 6, 1905. Serial No. 239,933.

807,244. Gas Stove. Charles Clamond, Paris, France. Filed Aug. 18, 1900. Serial No. 27,321.

807,245. Burning Gas to Develop Radiant Heat. Charles Clamond, Paris, France. Filed June 19, 1901. Serial No. 65,182.

807,246. Gas Stove. Charles Clamond, Paris, France. Original application filed August 18, 1900. Serial No. 27,321. Divided and this application filed March 10, 1905. Serial No. 249,409.

807,354. Gas Engine. Franz Burger, Fort Wayne, Ind., assignor of three-fourths to Henry M. Williams, Fort Wayne, Ind. Filed Feb. 13, 1902. Serial No. 92,945.

December 19.

807,594. Gas Producer. William H. Bradley, Bellevue, Pa., assignor of one-quarter to Alexander Gilliland, and one-quarter to William C. Bradley, Bellevue, Pa., and one-eighth to Sara L. Bradley, and one-eighth to Mrs. M. E. Webster, St. Louis, Mo. Filed July 21, 1904. Serial No. 217,571.

807,651. Incandescent Gas Burner. Charles J. Alexander, Finsbury, England. Filed Nov. 10, 1904. Serial No. 232,120.

807,813. Automatic Gas Regulator. Homer W. Fiske, Milan, O. Filed July 6, 1905. Serial No. 268,459.

807,950. Gas Engine. Robert Longtime and Edward Double, Los Angeles, Cal. Filed Aug. 17, 1904. Serial No. 221,062.

December 26.

808,244. Gas Producer. Ernest Korting, Hanover, Germany. Filed March 21, 1903. Serial No. 148,826.

808,365. Gas Generator. Henry A. Hartman, Philadelphia, Pa. Filed June 14, 1906. Serial No. 265,189.

808,403. Gas Regulator or Governor. George Reasner, New York, N. Y. Filed April 3, 1905. Serial No. 253,614.

808,572. Gas or Gasoline Engine. John Palmer, Philadelphia, Pa., assignor by direct and mesne assignments to F. S. Rutschmann, trustee, Philadelphia, Pa. Filed July 16, 1904. Serial No. 216,841.

January 2.

809,023. Gas Producer. Orville C. Skinner and James E. Sheaffer, Burnham, Pa. Filed July 27, 1904. Serial No. 218,352.

808,650. Gas Generator. Nelson Goodyear, Flushing, N. Y., assignor to J. B. Colt Co., a corporation of New York. Filed June 24, 1901. Serial No. 65,811.

809,077. **Gas Controller for Flash Lights and the Like.** Robert C. Roehl, Chicago, Ill. Filed March 6, 1905. Serial No. 248,622.

809,929. **Automatic Gas Danger Signal.** Preston A. Kettering, Cadiz, O. Filed May 31, 1904. Renewed June 6, 1905. Serial No. 264,015.

January 9.

809,292. **Gas Engine.** Wm. T. Fox, Rochester, N. Y. Filed Aug. 17, 1904. Serial No. 221,051.

809,339. **Fluid Sealing Device for Gas Producers.** Godfrey M. S. Tait, Montclair, N. J., assignor to the Combustion Utilities Co., New York, N. Y., a corporation of New York. Filed Aug. 17, 1905. Serial No. 274,639.

809,383. **Cleansing Manufactured Gas.** Leon P. Lowe, San Francisco, Cal. Filed June 17, 1903. Serial No. 161,795.

809,727. **Gas Fixture.** Patrick J. Nevins, Haverhill, Mass. Filed Feb. 23, 1905. Serial No. 246,880.

809,810. **Incandescent Gas Lamp.** John F. W. Jost, Philadelphia, Pa. Filed Nov. 29, 1904. Serial No. 234,721.

809,848. **Governor for Suction Gas Producers.** Erich Sandner, Lansing, Mich., assignor to the American Suction Gas Producer Co., Lansing, Mich., a corporation of Michigan. Filed June 26, 1905. Serial No. 267,139.

809,849. **Gas Producer.** Erich Sandner, Lansing, Mich., assignor to the American Suction Gas Producer Co., Lansing, Mich., a corporation of Michigan. Filed June 26, 1905. Serial No. 267,140.

January 16.

810,347. **Gas Engine.** Edwin F. Porter and Walter R. Whiting, Boston, Mass., assignors to American Rotary Engine Co., Boston, Mass., a corporation of Maine. Filed March 16, 1905. Serial No. 250,368.

January 23.

810,443. **Gas Valve.** John Sweeney, Johnstown, Pa. Filed June 30, 1905. Serial No. 267,772.

810,495. **Gas Engine.** William G. Miller, West Medway, Mass. Filed March 30, 1905. Serial No. 252,937.

810,562. **Gas Regulator.** Benjamin J. Petley, Seattle, Wash. Filed Feb. 23, 1905. Serial No. 246,818.

810,563. **Purifying Apparatus.** Pierre Plantinga, Cleveland, Ohio. Filed June 28, 1905. Serial No. 267,349.

810,565. Gas Engine. Edwin F. Porter and Walter R. Whiting, Boston, Mass., assignors to American Rotary Engine Co., Boston, Mass., a corporation of Maine. Filed Nov. 24, 1900. Serial No. 250,450.

810,653. Gas Burner. Samuel W. Hyatt, Mount Vernon, O. Filed Jan. 14, 1905. Serial No. 241,064.

810,685. Power Gas Apparatus. Godfrey M. S. Tait, Montclair, N. J., assignor to the Combustion Utilities Co., New York, N. Y., a corporation of New York. Filed Oct. 21, 1905. Serial No. 283,839.

810,870. High Pressure Gas Burner. William Kirkwood, Chicago, Ill. Filed March 13, 1905. Serial No. 249,894.

January 30.

811,050. Incandescent Gas Lamp. Louis C. Fuller, Kansas City, Mo. Filed June 3, 1905. Serial No. 263,518.

811,181. Gas Producer. Louis Sterne, London, England. Filed Aug. 18, 1904. Serial No. 221,279.

811,200. Electric Lighter and Extinguisher for Gas Burners. Oreste Candi and Cesar Candi, Genoa, Italy. Filed Nov. 17, 1904. Serial No. 233,174.

811,208. Gas Producer. Carleton Ellis, New York, N. Y., assignor to Combustion Utilities Co., New York, N. Y., a corporation of New York. Filed March 15, 1905. Serial No. 250,178.

811,399. Gas Burner. William C. Homan and Frank T. Williams, Meriden, Conn., assignors to Edward Miller & Co., Meriden, Conn., a corporation of Connecticut. Filed Jan. 5, 1905. Serial No. 239,695.

811,529. Gas Burner and Fixture Therefor. Robert M. Buckman, Medford, Mass. Filed April 13, 1905. Serial No. 255,421.

February 6.

811,588. Automatic Gas Controlling Device. Hugo Schneider, Cleveland, O. Filed Sept. 11, 1905. Serial No. 277,822.

811,595. Gas Operated Mechanism for Fire-arms. Cecil H. Taylor, Philadelphia, Pa., assignor by mesne assignments to Knox Taylor, Highbridge, N. J. Filed March 20, 1901. Renewed May 24, 1905. Serial No. 262,085.

811,757. Gas Engine. Vincent G. Apple, Dayton, O. Filed Dec. 5, 1904. Serial No. 235,583.

811,737. Gas Generating Apparatus. Charles L. Parsons, Durham, N. H. Filed July 23, 1904. Serial No. 217,844.

811,970. **Gas Burner.** Robert Swimmer, New York, N. Y., and Edward B. Neelen, Lyndhurst, N. J. Filed Nov. 21, 1904. Serial No. 233,696.

February 13.

812,217. **Gas Washer and Scrubber Combined.** Leon P. Lowe, San Francisco, Cal. Filed May 17, 1904. Serial No. 208,346.

812,218. **Gas Purifier.** Leon P. Lowe, San Francisco, Cal. Filed Nov. 7, 1904. Serial No. 231,616.

812,304. **Explosive Gas Engine.** Edward Shortt, Carthage, N. Y. Filed Sept. 24, 1902. Serial No. 124,702.

812,479. **Gas Retort Charging Device.** John W. Broadhead and Francis W. Ordish, Elland, England, assignors to Robert Dempster & Sons, limited, Elland, England. Filed June, 1905. Serial No. 265,916.

812,730. **Gas Controlling Device.** William T. Donnelly, New York, N. Y., assignor to General Gas Appliance Co., New York, N. Y., a corporation of New Jersey. Filed Dec. 20, 1904. Serial No. 237,623.

February 20.

812,975. **Gas Burner.** Samuel Bernheim, New York, N. Y. Filed May 16, 1905. Serial No. 260,622.

812,961. **Inverted Incandescent Gas Lamp.** Therese H. Steinicke, Berlin, Germany. Filed Nov. 29, 1904. Serial No. 234,793.

813,042. **Inverted Incandescent Gas Burner.** Henry Farnoff, Buffalo, N. Y. Filed Aug. 2, 1905. Serial No. 272,390.

813,097. **Gas Meter.** Kirk R. Howard, Chicago, Ill. Filed June 21, 1905. Serial No. 266,214.

813,312. **Dry Meter for Gas, Air and Like Fluids.** Daniel Macfie, Edinburg, Scotland. Filed Jan. 6, 1905. Serial No. 239,932.

813,357. **Gas Light Switch.** Thomas A. Davis, Findlay, O. Filed May 17, 1905. Serial No. 260,897.

February 27.

813,487. **Gas Lamp.** Robert M. Dixon, East Orange, N. J., assignor to The Safety Car Heating & Lighting Co., a corporation of New Jersey. Filed May 6, 1905. Serial No. 259,156.

813,575. **Apparatus for Lighting and Extinguishing Gas.** Richard N. Oakman, New York, N. Y. Filed May 27, 1905. Serial No. 262,567.

813,576. **Gas Conduit Controlling Apparatus.** Richard N. Oakman, New York, N. Y. Filed June 19, 1905. Serial No. 265,884.

813,600. **Gas Producer.** Edward W. Trump, Syracuse, N. Y. Filed Nov. 21, 1904. Serial No. 233,609.

813,628. **Operating Gas Producers.** Byron E. Eldred, Bronxville, N. Y., assignor to Combustion Utilities Company, New York, N. Y., a corporation of New York. Filed Aug. 10, 1905. Serial No. 273,668.

813,629. **Gas Producer.** Carleton Ellis, New York, N. Y., assignor to Combustion Utilities Co., New York, N. Y., a corporation of New York. Filed March 27, 1905. Serial No. 252,407.

813,726. **Gas Producing Apparatus.** Georges Marconnet, Paris, France. Filed Dec. 3, 1904. Serial No. 235,403.

March 6.

814,249. **Gas Producer.** James H. Swindell, Pittsburg, Pa. Filed Dec. 13, 1904. Serial No. 236,650.

814,279. **Gas Producing Apparatus.** Carleton Ellis, White Plains. N. Y. Filed Oct. 21, 1905. Serial No. 283,832.

814,359. **Gas Meter.** Samuel E. Crawford, Avalon, Pa. Filed Aug. 18, 1905. Serial No. 274,690.

814,459. **Inverted Incandescent Gas Burner.** Edwin Kramer, Berlin, Germany. Filed April 20, 1904. Serial No. 204,084.

814,609. **Gas Engine.** Edwin C. Kavanaugh, Holyoke, Mass. Filed May 17, 1904. Serial No. 208,400.

March 13.

814,698. **Gas Purifier.** Franklin G. Hobart, Beloit, Wis., assignor to Fairbanks, Morse & Co., Chicago, Ill., a corporation of Illinois. Filed April 20, 1905. Serial No. 256,632.

814,958. **Gas Meter.** Walter K. Harrington, Andover, N. J., assignor to Consolidated Gas Co., New York, N. Y., a corporation of New York. Filed Nov. 13, 1905. Serial No. 286,975.

815,099. **Gas Heater.** Levil F. Knoderer, Columbus, O. Filed Aug. 28, 1905. Serial No. 276,007.

March 20.

815,674. **Gas Purifier.** Quincy Bent, Lebanon, Pa. Filed June 23, 1905. Serial No. 213,814.

815,794. **Gas Producer.** Alberto Cerasoli, Rome, Italy. Filed April 22, 1904. Serial No. 204,433.

815,812. **Gas Purifying Apparatus.** Alexander M. Gow, Edgewood Park, Pa., assignor to Geo. Westinghouse, Pittsburg, Pa. Filed Aug. 1, 1904. Serial No. 218,975.

815,913. Gas Producer. Carleton Ellis, New York, N. Y., assignor to Combustion Utilities Co., New York, N. Y., a corporation of New York. Original application filed May 11, 1905. Serial No. 259,925. Divided and this application filed July 1, 1905. Serial No. 267,920.

March 27.

816,042. Gas Calorimeter. Charles E. Sargent, Chicago, Ill. Filed Sept. 8, 1905. Serial No. 277,572.

816,045. Gas Mixer. Marcus Scott, Jacksonville, Fla. Filed Oct. 26, 1905. Serial No. 284,498.

816,059. Gas Tank. Percy C. Avery, Dayton, O. Filed Oct. 17, 1904. Serial No. 288,810.

816,062. Gas Engine. Ira S. Barnett, Louisville, Ky. Filed Feb. 6, 1904. Serial No. 192,410

816,123 Gas Generator. John Radcliffe, Elland, England. Filed March 28, 1905. Serial No. 252,441.

816,215. Tandem Gas Engine. Leopold F. Burger, Anderson, Ind., assignor to Woolley Foundry & Iron Works, Anderson, Ind. Filed Feb. 2, 1905. Serial No. 243,826.

816,266. Gas Filter. Geo A. Stebbins, Watertown, N. Y. Filed May 6, 1905. Serial No. 259,110.

816,276. Gas Furnace. Ralph S. Thompson, Springfield, O., assignor to the Springfield Furnace Co., Springfield, O., a corporation of Ohio. Filed Nov. 23, 1904. Serial No. 233,982.

813,314. Making and Burning Fuel Gas. Walter T. Griffin, Plainfield, N. J. Filed Dec. 12, 1903. Serial No. 185,000.

816,427. Inverted Incandescent Gas Burner. James Bridger, London, England., assignor to The New Inverted Incandescent Gas Lamp Co., limited, London, England. Filed May 8, 1905. Serial No. 259,472.

816,549. Gas Engine. William Heckert, Findlay, O., assignor of one-half to H. W. Seney, Toledo, O. Original application filed June 13, 1902. Serial No. 111,537. Divided and this application filed May 18, 1903. Serial No. 157,608.

April 3.

816,973. Gas Producing and Consuming Apparatus. Carleton Ellis, New York, N. Y., assignor to Combustion Utilities Co., New York, N. Y., a corporation of New York. Filed Feb. 3, 1905. Serial No. 243,928.

817,009. Automatic Alarm for Gas Pipes. August L. Schultz, Cleveland, O., assignor of one-half to John H. Collister, Cleveland, O. Filed Nov. 28, 1904. Renewed Nov. 11, 1905. Serial No. 286,913.

817,035. Gas Generator. Johann L. Bormann, Charlottenburg, Germany. Filed Nov. 28, 1905. Serial No. 289.522.

817,126. Manufacturing Gas. Leon P. Lowe, San Francisco, Cal. Filed March 4, 1902. Serial No. 96,622.

817,127. Gas Washing Machine. Leon P. Lowe, San Francisco, Cal. Filed May 17, 1904. Serial No. 208,343.

April 10.

817,279. Gas Producing Apparatus. Jacob S. Smith, Chicago, Ill. Filed Feb. 8, 1905. Serial No. 244,790.

817,280. Producing Gas. Jacob L. Smith, Chicago, Ill. Filed June 10, 1905. Serial No. 264,562.

817,505. Automatic Gas Shut-off. Charles J. McCormick, Akron, O. Filed Nov. 9, 1904. Serial No. 232,037.

817,647. Gas Making Apparatus. Leon P. Lowe, San Francisco, Cal. Filed Jan. 30, 1905. Serial No. 243,170.

817,648. Gas Making Apparatus. Leon P. Lowe, San Francisco, Cal. Filed March 27, 1905. Serial No. 252,224.

817,649. Gas Manufacturing and Delivering Apparatus. Leon P. Lowe, San Francisco, Cal. Filed Aug. 8, 1905. Serial No. 273,311.

817,650. Gas Purifier. Leon P Lowe, San Francisco, Cal. Filed Dec. 13, 1905. Serial No. 291,641.

April 17.

817,853. Gas Producer. Franklin G. Hobart, Beloit, Wis., assignor to Fairbanks, Morse & Co., Chicago, Ill., a corporation of Illinois. Filed April 19, 1905. Serial No. 256,415.

818,033. Gas Furnace or Coke Oven. Heinrich Koppers, Essen-on-the-Ruhr, Germany. Filed Feb. 7, 1905. Serial No. 244,553.

818,151. Gas Furnace. Davis A. Ebinger, Columbus, O., assignor to Columbus Heating & Ventilating Co., Columbus, O., a corporation of Ohio. Filed May 22, 1905. Serial No. 261,682.

April 24.

818,891. Gas Purifier. Edward C. Jones, San Francisco, Cal., and S. T. Wellman, Cleveland, O. Filed July 1, 1904. Serial No. 214,980.

May 1.

819,075. Gas Producer. Charles H. Morgan, Worcester, Mass. Filed June 3, 1904. Serial No. 210,960.

819,074. Gas Generating Machine. Orville V. Monroe, Portland, Ore., assignor by direct and mesne assignments to General Promoting Co., Portland, Ore. Filed May 15, 1905. Serial No. 260,519.

819,492. Gas Controller. Thomas B. Wylie, Pittsburg, Pa. Filed May 23, 1905. Serial No. 261,905.

819,660. Gas Washer. Leon P. Lowe, San Francisco, Cal. Filed March 27, 1905. Serial No. 252,226.

819,661. Manufacturing Gas. Leon P. Lowe, San Francisco, Cal. Filed April 7, 1904. Serial No. 201,970.

819,662. Gas Making Apparatus. Leon P. Lowe, San Francisco, Cal. Filed April 7, 1904. Serial No. 201,971.

819,663. Coking and Making Gas. Leon P. Lowe, San Francisco, Cal. Filed May 3, 1904. Serial No. 206,245.

819,664. Apparatus for Separating Residues from Liquids. Leon P. Lowe, San Francisco, Cal. Filed May 17, 1904. Serial No. 208,344.

819,665. Gas Holder. Leon P. Lowe, San Francisco, Cal. Filed May 7, 1904. Serial No. 208,345.

819,666. Gas Generating Apparatus. Leon P. Lowe, San Francisco, Cal. Filed Dec. 5, 1905. Serial No. 290,333.

May 7.

819,830. Gas Exhauster. John T. Wilkin, Connersville, Ind. Filed Jan. 30, 1905. Serial No. 243,214.

819,980. Acetylene Gas Generator. Melvin D. Compton, New York, N. Y., assignor to Frank Fuller, New York, N. Y. Filed Oct. 3, 1901. Serial No. 77,344.

820,247. Gas Cleaning Machine. Carl O. Nordensson, Scane, Sweden, assignor of one-half to John A. Laird, St. Louis, Mo. Filed Sept. 11, 1905. Serial No. 277,853.

May 15.

820,485. Producing Gas. Byron E. Eldred, New York, N. Y., assignor to Combustion Utilities Co., New York, N. Y., a corporation of New York. Filed May 11, 1905. Serial No. 259,939

820,497. Gas Engine. Frederick H. Hurlburt, Alameda, and Thomas W. Monroe, San Francisco, Cal. Filed Feb. 24, 1905. Serial No. 247,105.

820,525. **Method of Treating and Utilizing Gas.** Frederick W. C. Schniewind, Everett, Mass., assignor to the United Coke & Gas Co., Charlestown, W. Va., a corporation of West Virginia. Filed Jan. 22, 1900. Serial No. 2,313.

820,563. **Gas Meter.** James Green, Brooklyn, N. Y. Filed July 10, 1905. Serial No. 268,739.

820,772. **Gas Purifying Apparatus.** Albert Elsenhaus, Rüttenscheid, near Essen-on-the-Ruhr, Germany. Filed Jan. 10, 1906. Serial No. 295,449.

820,891. **Gas Engine.** John C. Scovel, Jr., Chicago, Ill. Filed Dec. 16, 1904. Serial No. 237,160.

May 22.

821,258. **Gas Generating Apparatus.** Henry B. Rouse, Chicago, Ill. Filed Oct. 20, 1905. Serial No. 283,645.

821,425. **Gas Cleaner.** Patrick Meehan, Lowellville, O. Filed Jan. 20, 1905. Serial No. 241,988.

821,594. **Gas Making Apparatus.** Leon P. Lowe, San Francisco, Cal. Filed Nov. 8, 1905. Serial No. 286.329.

May 29.

821,928. **Making Gas.** Fritz Dannert, Berlin, Germany, assignor to Julius A. Hutmacher, Berlin, Germany. Filed Oct. 23, 1905. Serial No. 283,876.

821,995. **Gas Producing and Consuming Apparatus.** Carleton Ellis, New York, N. Y., assignor to Combustion Utilities Co., New York, N. Y., a corporation of New York. Filed March 28, 1905. Serial No. 252,487.

822,132. **Gas Generator.** Abram H. Jones, Hartford City, Ind. Filed July 24, 1905. Serial No. 271,002.

June 5.

822,246. **Gas Producing Apparatus.** Julius Bueb, Dessau, Germany. Filed Aug. 18, 1905. Serial No. 274,119.

822,531. **Manufacturing Gas.** Leon P. Lowe, San Francisco, Cal. Filed Aug. 24, 1905. Serial No. 275,534.

822,771. **Gas Mixer.** Oscar Robbel, Kenosha, Wis. Filed Aug. 5, 1905. Serial No. 272,849.

822,781. **Gas Producer Charging Door.** Harry F. Smith, Lexington, O. Filed May 24, 1905. Serial No. 262,025.

June 12.

823,450. **Gas Engine.** Benjamin F. Stewart, Chicago, Ill. Filed Feb. 10, 1905. Serial No. 245,080.

June 26.

824,337. **Gas Generating Furnace.** Charles A. Buzzell, Newburyport, Mass. Filed July 10, 1905. Serial No. 269,050.

824,338. **Gas Heating Apparatus.** Augustus C. Carey, Boston, Mass. Filed May 22, 1903. Serial No. 158,368.

824,353. **Gas Producer.** Heinrich Gerdes, Berlin, Germany, assignor to American Suction Gas Producer Co., Lansing, Mich., a corporation of Michigan. Filed July 31, 1905. Serial No. 272,058.

824,358. **Suction Gas Producer.** Eugene Higgins, Lansing, Mich., assignor to American Suction Gas Producer Co., Lansing, Mich., a corporation of Michigan. Filed Aug. 5, 1905. Serial No. 272,858.

824,359. **Gas Producer.** Robert Hilprecht, Lansing, Mich., assignor to American Suction Gas Producer Co., Lansing, Mich., a corporation of Michigan. Filed June 17, 1905. Serial No. 265,778.

824,384. **Gas Producer.** Erich Sandner, Lansing, Mich., assignor to American Suction Gas Producer Co., Lansing, Mich. Filed July 31, 1905. Serial No. 272,079.

824,419. **Prepayment Attachment for Gas Meters.** Rudolph L. Fersenheim, New York, N. Y. Filed Oct. 1, 1903. Serial No. 175,254.

July 3.

824,786. **Gas Purifier.** Perry E. Hall, Jr., Everett, Wash. Filed Dec. 27, 1905. Serial No. 293,507.

824,883. **Gas Producer.** Josef Reuleaux, Wilkinsburg, Pa. Filed Oct. 6, 1905. Serial No. 281,663.

824,999. **Gas Analysis Apparatus.** John M. Morehead, Chicago, Ill. Filed June 17, 1905. Serial No. 265,797.

825,187. **Gas Meter Prepayment Attachment.** Louis T. Bulley, New Haven, Conn. Filed May 15, 1905. Serial No. 260,399.

July 10.

825,324. **Wet Gas Meter.** John Oswell Jones, St. Louis, Mo. Filed Sept. 11, 1905. Serial No. 278,057.

July 17.

825,214. **Gas Manufacture Apparatus.** John E. Allen, Columbiana, O., administrator of James J. Johnston, deceased, assignor to Albert C. Ellis, Pittsburg, Pa. Filed Sept. 17, 1897. Serial No. 652,051.

826,511. Manufacturing Gas. John E. Allen, Columbiana, O., administrator of James J. Johnston, deceased, assignor to Albert C. Ellis, Pittsburg, Pa. Original application filed Sept. 17, 1897. Serial No. 652,051. Divided and this application filed Nov. 14, 1902. Serial No. 131,319.

July 24.

826,691. Gas Purifying Apparatus. Schuyler F. Seager, Lansing, Mich., assignor to American Suction Gas Producer Co., Lansing, Mich., a corporation of Michigan. Filed Dec. 20, 1905. Serial No. 292,570.

826,747. Gas Purifying Apparatus. Thomas Redman, Bolton, Bradford, England. Filed Aug. 22, 1904. Serial No. 221,776.

July 31.

827,075. Apparatus for the Manufacture of Illuminating Gas. Carl W. Bilfinger, Brooklyn, N. Y., assignor of one-fourth to Columbia Engineering Works, a corporation of New York, and one-sixteenth to Absalom P. Bachman, New York, N. Y. Filed June 22, 1904. Serial No. 213,678.

827,081. Apparatus for Manufacturing Gas. Philip I. Cohen, New York, N. Y. Filed Nov. 7, 1905. Serial No. 286,314.

August 7.

827,755. Incandescent Gas Burner. Milton H. Samson, Chicago, Ill. Filed Oct. 18, 1905. Serial No. 283,218.

827,759. Gas Engine. Harry J. Smith, Buffalo, N. Y. Filed Feb. 2, 1903. Serial No. 141,408.

827,810. Gas Engine. Peter Mohrdieck, San Francisco, Cal., assignor to Standard Gas Engine Co., San Francisco, Cal., a corporation. Filed April 13, 1903. Serial No. 152,306.

827,835. Gas Main Bag. John H. White, Jersey City, N. J., assignor of one-half to A. Bell Malcolmseon, West Orange, N. J. Filed Nov. 17, 1904. Serial No. 233,065.

827,862. Producing Gas. Heinrich Gerdes, Berlin, Germany, assignor to American Suction Gas Producer Co., Lansing, Mich., a corporation of Michigan. Filed July 31, 1905. Serial No. 272,057.

August 14.

828,306. Gas Calorimeter. Henry L. Doherty, Madison, Wis., assignor to Combustion Utilities Co., a corporation of New York. Filed March 15, 1905. Serial No. 250,196.

828,399. Acetylene Gas Generator. Myer Goldstein, Johannesburg, Transvaal. Filed Sept. 12, 1905. Serial No. 278,099.

828,813. Gas Controlling Apparatus. Joseph Higginson, Jr., Stockport, England. Filed Feb. 7, 1905. Serial No. 244,681.

August 21.

829,060. Device for Automatically Regulating the Supply of Steam to Gas Producers. Joseph Delassne, Paris, France. Filed Dec. 22, 1903. Serial No. 186,236.

829,105. Regulating the Temperature of Combustion in Gas Producers. Henry L. Doherty, Madison, Wis., assignor by mesne assignments to Combustion Utilities Co., New York, N. Y., a corporation of New York. Filed Oct. 25, 1904. Serial No. 229,910.

829,136. Gas Burner Safety Attachment. Stephen H. Blodgett, South Lincoln, Mass. Filed April 18, 1905. Serial No. 256, 241.

829,279. Gas Engine. Bernard B. Mears, Baltimore, Md. Filed March 21, 1905. Serial No. 251,283.

829,248. Acetylene Gas Generator. John W. Nunn and Thomas D. Griffin, Granger, Tex. Filed May 18, 1905. Serial No. 260,998.

August 28.

829,518. Gas Producing Apparatus. Walter A. Fourness, New York, N. Y. Filed Sept. 27, 1905. Serial No. 280,286.

829,541. Gas Producer. Joseph G. Nash, Adelaide, Australia. Filed Sept. 6, 1904. Serial No. 223,511.

829,651. Gas Producer. William B. Hughes, Philadelphia, Pa. Filed Oct. 21, 1905. Serial No. 283,750.

829,700. Gas Purifying Apparatus. Michel Drees, Aplerbeck, Germany. Filed Feb. 20, 1905. Serial No. 246,417.

829,919. Apparatus for Producing Power Gas. Ludwig Hertzog, Berlin-Südende, assignor to the firm of Adolph Saurer, Arbon, Switzerland. Filed Sept. 10, 1904. Serial No. 244,044.

September 4.

830,015. Gas Generating Apparatus. Melville D. Shaw and William P. Rhody, Wapakoneta, O. Filed March 5, 1906. Serial No. 304,329.

830,017. Gas Mixer. Frederick Smith, Camden, N. J. Filed Nov. 17, 1905. Serial No. 287,911.

830,092. Device for Intermittent Gas Lights. Charles Matthews, Jr., and Ernest E. Laun, Chicago, Ill. Filed Feb. 8, 1905. Serial No. 244,770.

830,270. Gas Engine. Reuben Willetts, Butler, Pa. Filed May 25, 1905. Serial No. 262,195.

September 11.

830,591. Grate for Gas Producers. Robert Hilprecht, Lansing, Mich., assignor to American Suction Gas Producer Co., Lansing, Mich., a corporation of Michigan. Filed June 26, 1905. Serial No. 267,135.

830,758. Gas Burner. Lee T. Alton, New York, N. Y. Filed Sept. 14, 1905. Serial No. 278,413.

830,833. Gas Generator. William H. Cone, Berlin, Ontario, Canada., assignor to Cone Gas Machine Co., Detroit, Mich., a corporation of Michigan. Filed June 7, 1905. Serial No. 264,173.

830,884. Gas Producer. William H. Cone, Berlin, Ontario, Canada, assignor to Cone Gas Machine Co., Detroit, Mich., a corporation of Michigan. Original application filed June 7, 1905. Serial No. 264,173. Divided and this application filed Aug. 31, 1905. Serial No. 276,611.

830,968. Gas Producer. Grant Campion & Mott Wyant, Anderson, Ind. Filed June 22, 1905. Serial No. 266,404.

830,919. Gas Igniting and Extinguishing Device. Richard N. Oakman, New York, N. Y. Filed June 2, 1905. Serial No. 263,412.

830,974. Gas Consuming Furnace for Crematories. Felix L. Decarie, Minneapolis, Minn., assignor to Decarie Mfg. Co., Minneapolis, Minn., a corporation of Minnesota. Filed Nov. 21, 1904. Serial No. 233,619.

830,983. Treating Coal Gas for Extracting Tar, Water and Ammonia. Walter Feld, Honningen-on-the-Rhine, Germany. Filed Jan. 4, 1906. Serial No. 294,668.

831,013. Distant Acting Electrical Gas Igniter. George Leutschat, Hohen-Schonhausen, near Berlin, Germany, assignor of one-half to Wenzel L. Drahonowsky, Miroschau, Austria-Hungary. Filed July 24, 1906. Serial No. 327,468.

831,022. Gas Apparatus. Louis W. Watts, Hartley, Iowa, assignor by mesne assignments to Adolph Schwartz, Hennepin County, Minn. Filed Sept. 6, 1904. Serial No. 223,397.

September 18.

831,048. Gas Engine. Fay O. Farwell, Dubuque, Iowa. Filed Jan. 21, 1901. Serial No. 44,162.

831,053. Gas Holder. William Gadd, Manchester, England. Filed Dec. 27, 1905. Serial No. 293,529.

831,060. Gas Igniting and Extinguishing Device. Fritz S. Grünfeld, Berlin, Germany. Filed April 22, 1905. Serial No. 256,971.

831,213. Gas Cut-off. Victor E. Campbell, Goldendale, Wash. Filed April 11, 1906. Serial No. 311,149.

831,262. Gas Supply Regulating and Controlling Means. William H. Cain, Columbus, O., assignor of one-half to Charles A. Gass, Columbus, O. Filed Sept. 29, 1905. Serial No. 280,662.

831,512. Gas Jet Regulator. Charles J. Johnson, St. Louis, Mo., assignor of one-third to Frederick Horn, St. Louis, Mo. Filed Feb. 5, 1906. Serial No. 299,554.

September 25.

831,695. Gas Pipe Thawing Attachment. John Zvetina, Chicago, Ill. Filed March 30, 1905. Serial No. 252,928.

831,854. Gas Producer. Alexander M. Gow, Edgewood Park, Pa. Filed March 10, 1905. Serial No. 249,436.

UNITED STATES PATENTS RELATING TO GAS.

EXPIRED FROM OCTOBER 1, 1905, TO SEPTEMBER 30, 1906.

October 2.

390,352. **Heating Gas Burner.** A. J. Doty, Philadelphia, Pa., assignor by mesne assignments to the Goodwin Gas Stove & Meter Co., same place. Filed March 26, 1887.

390,377. **Gas Stove.** J. Laxton, Toronto, Ontario, Canada. Filed Oct. 20, 1887.

390,568. **Gas Pressure Regulator.** J. W. Carter and J. Miller, Greenfield, Ind. Said Miller assignor to Winfield S. Gant, same place. Filed April 26, 1888.

October 9.

390,660. **Gas Burner.** J. E. Gill and T. M. Foley, Franklin, Pa. Filed Nov. 5, 1887.

390,706. **Portable Gas Stand.** E. S. Rich, New York, N. Y. Filed June 16, 1887.

390,710. **Gas Engine.** H. K. Shanck, Columbus, O. Filed Oct. 5, 1887.

390,743. **Gas Log and Fire Place.** Q. S. Bachus, Winchendon, Mass. Filed Nov. 9, 1886.

390,761. **Gas Check for Waste Pipes.** H. B. Eareckson, New York, N. Y. Filed April 24, 1888.

390,836. **Gas Compressing and Refrigerating Apparatus.** L. Block, New York, N. Y. Filed March 17, 1887.

391,000. **Gas Lamp.** C. Westphal, Berlin, Germany, assignor of one half to Julius Quaglio, same place. Filed Nov. 22, 1887.

October 16.

391,175. **Gas Burner.** J. H. McQuaid, Farmers Valley, Pa. Filed Feb. 25, 1888.

391,365. **Gas Burner for Stoves.** C. M. Gummer, Dayton, O., assignor to the Gem City Stove Co., same place. Filed April 2, 1888.

391,354. **Machine for Slotting Metallic Gas Tips.** W. Carey, Montreal, Quebec, Canada., assignor to J. B. Hogue and Charles Salter, same place. Filed March 12, 1888.

391,386. **Manufacturing Water Gas.** J. M. Rose, Allegheny, Pa., assignor to the Rose Gas Generator Co. of N. J. Filed March 2, 1887.

391,387. **Apparatus for the Manufacture of Water Gas.** J. M. Rose, Allegheny, Pa., assignor to Rose Gas Generator Co. of N. J. Original application filed March 2, 1887. Divided and this application filed Nov. 1, 1887.

October, 23.

391,399. **Device for Heating Water by Gas.** W. M. Brown, Albany, N. Y. Filed Feb. 20, 1888.

391,486. **Gas Engine.** W. S. Sharpneck, Chicago, Ill. Filed Dec. 23, 1887.

391,528. **Gas Engine.** H. Hartig, Brooklyn, N. Y. Filed Nov. 22, 1887.

391,537. **Gas Burner.** J. A. Kloeb, Dunkirk, Ind. Filed Dec. 1, 1887.

391,606. **Gas Burner for Heating Purposes.** J. Hauck, Baltimore, Md. Filed March 2, 1888.

391,758. **Globe for Gas Burners.** C. C. Morley and H. C. Hinchcliff, New York, N. Y., assignors to said C. C. Morley. Filed Nov. 14, 1887.

October 30.

391,865. **Oil and Gas Burner.** L. Schutte, Philadelphia, Pa. Filed Nov. 5, 1887.

391,866. **Regenerative Gas Burner.** W. Stern, Berlin, Germany. Filed March 1, 1888.

392,089. **Gas Governor.** E. Williams and G. Fewlass, Newport, Ky. Filed March 6, 1888.

392,109. **Anti-fluctuator for Gas Engines.** J. R. Daly, New Orleans, La. Filed March 17, 1888.

392,129. **Method of Making Incandescent Gas Burners.** E. Moreau, Philadelphia, Pa. Filed Feb. 20, 1888.

November 6.

392,175. **Furnace Gas Burner.** J. S. Andrews, New York, N. Y., and J. S. Rodgers, Rockport, Mass. Filed May 25, 1887.

392,191. Gas Engine. H. T. Dawson, Salcombe, County of Devon, England. Filed Nov. 15, 1887.

392,340. Gas Governor. F. G. Johnson, New York, N. Y. Filed June 21, 1888.

392,406. Gas Main. H. C. Campbell, Pittsburg, Pa. Filed Feb. 16, 1888.

392,434. Regenerative Gas Burner. W. S. Horry, New York, N. Y., assignor by direct and mesne assignments to the United States Incandescent Gas Lamp Co. Filed Feb. 8, 1888.

392,440. Electric Gas Lighter. J. H. Lehman, Philadelphia, Pa. Filed Dec. 20, 1887.

392,447. Pressure Regulator. W. Meyer, New York, N. Y. Filed June 21, 1888.

392,458. Manufacture of Gas. H. M. Pierson, Brooklyn, N. Y. Filed Feb. 3, 1888.

392,489. Pressure Regulator for Gas Burners. O. W. Bennett, Washington,D. C. Filed March 3, 1888.

392,527. Regenerative Gas Burner. H. Schwidlinsky, Berlin, Germany, assignor to A. Kuhnt & R. Deissler, both of same place. Filed Feb. 23, 1888.

392,553. Apparatus for Manufacturing Gas. Magnus Gross, New York, N. Y. Filed Dec. 17, 1887.

392,554. Apparatus for Manufacturing Gas. Magnus Gross, New York, N. Y. Filed Dec. 17, 1887.

392,555. Apparatus for Manufacturing Gas. Magnus Gross, New York, N. Y. Filed Dec. 17, 1887.

November 13.

392,665. Electric Gas Lighter. H. A. Cleverly, Philadelphia, Pa. Filed May 28, 1888.

392,701. Electric Machine for Lighting and Extinguishing Gas. G. E. Thaxter, Boston, Mass. Filed August 4, 1888.

392,897. Regenerative Gas Furnace. O. B. Weber, New York, N. Y. Filed June 5, 1888.

392,921. Automatic Gas Extinguishing Apparatus. R. Howard, Salt Lake City, Utah. Filed May 2, 1888.

November 20.

392,986. Gas Burning Steam Generator. W. M. Brown, Albany, N. Y. Filed May 23, 1888.

392,993. **Gas Fixture.** M. P. Coleman, Boston, Mass. Filed March 23, 1888.

393,008. **Automatic Feed Regulator for Gas Burners.** C. D. Harris, Cicero, Ind. Filed May 24, 1888.

393,077. **Gas Burner.** J. N. Pew, Pittsburg, Pa. Filed June 12, 1888.

393,094. **Gas Stove.** C. L. Bisbee, Brooklyn, N. Y. Filed Feb. 9, 1888.

393,134. **Manufacturing Gas.** G. M. Westman, New York, N. Y. Filed May 1, 1888.

393,271. **Apparatus for Automatically Lighting and Extinguishing Gas Burners.** N. H. Shaw, Somerville, Mass., assignor by direct and mesne assignments to the American Automatic Gas Lighting Co., Portland, Me. Filed Oct. 8, 1887.

393,304. **Electric Gas Lighter.** C. H. Haskins, New York, N. Y. Filed June 7, 1887.

November 27.

393,396. **Natural Gas Protective Extinguisher.** C. E. Scribner, Chicago, Ill., assignor to Western Electric Co., same place. Filed June 1, 1886.

393,501. **Device for Reducing Pressure in Water or Gas Pipes.** C. Delafield, Mobile, Ala. Filed May 11, 1888.

393,525. **Automatic Gas Lighting and Extinguishing Apparatus.** N. H. Shaw, Somerville, Mass., assignor to the American Automatic Gas Lighting Co., Portland, Me. Filed Jan. 23, 1888.

393,617. **Gas Retort Lid.** Z. L. Chadbourne, Brooklyn, N. Y., assignor of one half to V. E. Downer, Lyndhurst, N. J., and V. Vierow, New York, N. Y. Filed Jan. 26, 1888.

393,724. **Gas Holder.** Thomas F. Rowland, New York, N. Y. Filed Feb. 6, 1888.

December 4.

393,764. **Burner for Gas Cooking Stove.** I. F. Kearns, Chicago, Ill. Filed Jan. 9, 1888.

393,977. **Mixing and Injecting Apparatus for Making Gas.** Magnus Gross, New York, N. Y. Filed Dec. 10, 1887.

394,004. **Gas Stove.** M. J. O'Reilly, Buffalo, N. Y. Filed Feb. 13, 1888.

394,080. **Valve Apparatus for Gas or Oil Motor Engines.** N. A. Otto, Cologne, assignor to the Gas-Motoren-Fabrik-Deutz, Deutz, Germany. Filed July 31, 1888.

394,101. Gas Burner. E. B. Cutten, Corry, Pa., assignor to J. J. Steytler, trustee, same place. Filed Jan. 24, 1887. Renewed Dec. 2, 1887.

December 11.

394,214. Apparatus for Testing Mine Gases. T. Shaw, Philadelphia, Pa. Filed Oct. 21, 1887.

394,215. Apparatus for Testing Mine Gases. T. Shaw, Philadelphia, Pa. Filed Feb. 6, 1888.

394,299. Gas or Caloric Engine. A. Rollason, Newcastle-on-Tyne, County of Northumberland, England. Filed June 2, 1888.

December 18.

394,597. Automatic Cut-off for Gas Mains. G. W. McKenzie, Vanport, assignor to the Beaver Mfg. Co., Beaver County, Pa. Filed Dec. 19, 1887.

394,620. Conduit for Gas or Other Fluids. C. R. Spehler, Pittsburg, Pa., assignor by direct and mesne assignments to Geo. Westinghouse, Jr., same place. Filed Jan. 22, 1885.

394,645. Gas Burner. D. Z. Evans, Philadelphia, Pa. Filed Dec. 20, 1887.

December 25.

395,044. Gas Compressing Pump for Ice Machines. Thomas Farnsworth, San Antonio, Texas. Filed March 31, 1888.

395,125. Regenerative Gas Burner. A. J. English, Cincinnati, O., assignor of one-half to Powell Crosley, same place. Filed August 26, 1887.

January 1.

395,334. Automatic Gas Cut-off. C. M. Kirkpatrick, Indianapolis, Ind., assignor of one-half to Joseph M. Taylor, same place. Filed Oct. 8, 1888.

395,387. Automatic Gas Regulator and Cut-off. E. H. Ford, Hartford City, Ind. Filed Feb. 27, 1888.

395,449. Apparatus for the Manufacture of Gas. J. A. McCollum, Riverside Cal. Filed August 1, 1888.

395,560. Cut-off device for Gas. L. B. Fulton, Pittsburg, Pa. Filed May 7, 1888.

January 8.

396,022. Gas Engine. J. C. Beckfeld, Allegheny, Pa., assignor of one-half to Albert Schmid, same place. Filed Nov. 23, 1887.

396,039. **Coupling for Gas and Electric Light Fixtures.** R. Herman, Crafton, assignor to Geo. H. Blaxter, Pittsburg, Pa. Filed May 2, 1888.

January 15.

396,253. **Incandescent Gas Burner.** Harold J. Bell, Woodbury, N. J., assignor to the Welsbach Incandescent Gas Light Co. of N. J. Filed March 8, 1888.

396,254. **Incandescent Gas-Burner.** Harold J. Bell, Woodbury, N. J., assignor to the Welsbach Incandescent Gas Light Co. of N. J. Filed March 21, 1888.

396,255. **Atmospheric Gas Burner.** Harold J. Bell, Gloucester City, N. J., assignor to the Welsbach Incandescent Gas Light Co. of N. J. Filed May 10, 1888.

396,256. **Atmospheric Gas Burner.** Harold, J. Bell, Gloucester City, N. J., assignor to the Welsbach Incandescent Gas Light Co. of N. J. Filed May 19, 1888.

396,257. **Gas Regulating Burner.** Harold J. Bell, Gloucester City, N. J., assignor to the Welsbach Incandescent Gas Light Co. of N. J. Filed May 19, 1888.

396,258. **Gas Regulating Burner.** Harold J. Bell, Gloucester City, N. J., assignor to the Welsbach Incandescent Gas Light Co. of N. J. Filed May 19, 1888.

396,259. **Gas Regulating Burner.** Harold J. Bell, Gloucester City, N. J., assignor to the Welsbach Incandescent Gas Light Co. of N. J. Filed May 19, 1888.

396,260. **Incandescent Gas Burner.** Harold J. Bell, Woodbury, N. J., assignor to the Welsbach Incandescent Gas Light Co. of N. J. Filed March 2, 1888.

396,322. **Gas Incandescent.** Harold J. Bell, Gloucester City, N. J., assignor to Welsbach Incandescent Gas Light Co., Jersey City, N. J. Filed July 2, 1888.

396,332. **Apparatus for Lifting the Covers of Gas Purifiers.** J. R. Floyd, New York, N. Y. Filed June 2, 1888.

396,238. **Gas Engines.** A. Schmid, Pittsburg, Pa. Filed May 2, 1887.

January 22.

396,575. **Gas Stove.** L. Ketchum, Saugatuck, Conn. Filed Nov. 25, 1887.

396,576. **Gas Stove.** L. Ketchum, Saugatuck, Conn. Filed April 10, 1888.

January 29.

396,746. **Gas Retort.** W. C. Jones, Waxahachie, Texas. Filed Dec. 1, 1887.

396,768. **Gas Machine.** E. D. Self, South Orange, N. J. Filed July 19, 1887.

396,899. **Automatic Gas Governor.** R. H. Speake, Washington D. C., assignor of two-thirds to Charles A. McCuen, Charles E. Eberle and Henry C. Borden, all of the same place. Filed March 10, 1888.

396,995. **Regulator for Gas Lamps.** J. Franklin, Cincinnati, O. Filed Dec. 20, 1887.

February 5.

397,205. **Gas Machine.** E. D. Self, South Orange, N. J. Filed Jan. 9, 1888.

397,397. **Apparatus for the Manufacture of Gas.** R. H. Smith, Pittsburg, Pa. Filed Dec. 15, 1887.

February 12.

10,985. **Gas Burner.** C. B. Todd, Pittsburg, Pa., (re-issue) assignor to Campbell Burner Co. (Limited), same place. Filed June 19, 1888.

397,639. **Apparatus for the Manufacture of Gas.** J. C. Garvin and H. Moody, Leadville, Colo. Filed March 31, 1888.

397,753. **Gas Engine Governor.** D. S. Regan, San Francisco, Cal., assignor to himself and S. S. Bennett, Alameda, Cal. Filed April 4, 1888.

397,836. **Apparatus for Supplying Steam to Cups of Telescopic Gas Holders.** S. Cutler, Millwall, County of Middlesex, England. Filed Nov. 16, 1888.

February 19.

397,907. **Gas Generating Furnace.** J. Gilbert, Omaha, Neb., assignor of one-half to Charles E. Lee, same place. Filed March 13, 1888.

398,021. **Gas Regulator.** J. Bardsley, Oldham, County of Lancaster, England. Filed June 25, 1888.

398,051. **Gas Generator.** J. Jordan, Bridgeport, Pa. Filed Nov. 14, 1888.

398,108. **Gas Motor.** C. T. A. H. Wiedling, New York, N. Y., assignor to John S. Connelly, Plainfield, N. J. and Thomas E. Connelly, Brooklyn, N. Y. Filed Dec. 22, 1887.

398,306. **Apparatus for the Manufacture of Gas.** J. D. Averell, Brooklyn, N. Y., assignor by mesne assignments to Jose F. Toraya, Philadelphia, Pa. Filed Oct. 23, 1886.

397,904. **Gas Burner for Billiard Tables.** Wm. P. Folmer, New York, N. Y., assignor of one-half to Walter E. Schwing, same place. Filed July 27, 1888.

February 26.

398,384. **Coal Gas Condenser.** F. J. Davis, Waltham, Mass. Filed July 1, 1887.

398,404. **Regenerative Gas Burner.** F. G. Johnson, New York, N. Y. Filed Feb. 15, 1888.

398,707. **Gas Meter.** J. W. Culmer, New Brighton, Pa., assignor to John H. Logan, same place. Filed August 29, 1888.

398,708. **Plural Piston Gas Meter.** John W. Culmer, New Brighton, Pa., assignor to John H. Logan, same place. Filed August 29, 1888.

398,721. **Gas Meter.** J. J. Harrell, New Brighton, Pa., assignor to John H. Logan, trustee, same place. Filed August 28, 1888.

March 5.

398,881. **Gas Regulator.** E. J. Colby, Chicago, Ill. Filed May 26, 1888.

399,022. **Gas Stove.** A. S. Dinsmore, Boston, Mass. Filed Feb. 16, 1888.

399,087. **Apparatus for the Manufacture of Gas.** Henry C. Shields, Troy, N. Y. Filed Dec. 16, 1887.

399,104. **Gas Burner.** Fernando White, Pittsburg, Pa., assignor of one-half to William Yagle & Co. (Limited), same place. Filed March 15, 1888.

March 12.

399,290. **Regenerative Gas Burner.** F. Siemens, Dresden, Saxony, Germany. Filed Oct. 30, 1886.

399,416. **Electric Gas Lighter.** E. Kronenberg, Philadelphia, Pa. Filed Oct. 17, 1888.

399,427. **Apparatus for Separating Liquids from Natural Gas.** William Moore, Kokomo, Ind. Filed May 21, 1888.

399,497. **Combined Gas and Electric Light Fixture.** J. C. Cassidy, East Orange, N. J. Filed Jan. 3, 1889.

March 19.

399,793. **Gas Producer.** Wm. J. Taylor, Chester, Pa., assignor to the Taylor Gas Producer Co. of Camden, N. J. Filed Dec. 31, 1886.

399,794. **Gas Producer.** Wm. J. Taylor, Chester, Pa., assignor to the Taylor Gas Producer Co. of Camden, N. J. Filed May 2, 1887.

399,795. **Gas Producer.** Wm. J. Taylor, Chester, Pa., assignor to the Taylor Gas Producer Co. of Camden N. J. Filed May 2, 1887.

399,796. **Gas Producer.** Wm. J. Taylor, Chester, Pa., assignor to the Taylor Gas Producer Co. of Camden, N. J. Filed May 21, 1887.

399,798. **Method of Making Gas.** W. J. Taylor, Chester, Pa., assignor to Taylor Gas Producer Co. of Camden, N. J. Filed Feb. 13, 1888.

399,799. **Gas Producer.** Wm. J. Taylor, Chester, Pa., assignor to the Taylor Gas Producer Co. of Camden, N. J. Filed May 2, 1887. Renewed Oct. 12, 1888.

399,907. **Gas Engine.** S. Lawson, N. Y., assignor to himself and Alonzo T. Welch, same place. Filed Feb. 6, 1888.

399,908. **Gas Engine.** S. Lawson, New York, N. Y., assignor to himself and Alonzo T. Welch, same place. Filed August 4, 1888.

399,948. **Gas Burner** William P. Tibbens, Buffalo, N. Y., assignor of three-fourths to Martin B. Daly, same place. Filed Jan. 18, 1888.

March 26.

400,060. **Apparatus for the Manufacture of Gas.** W. M. Cosh, Baltimore, Md. Filed Jan. 12, 1888.

400,072. **Regenerative Gas Burner.** E. Fullford and H. T. Van Laun, London, England. Filed July 18, 1888.

400,073. **Regenerative Gas Burner.** E. Fullford and H. T. Van Laun, London, England. Filed July 18, 1888.

400,163. **Gas Engine.** T. B. Barker, Birmingham, County of Warwick, England. Filed Jan. 5, 1889.

400,166. **Incandescent Gas Burner.** Harold J. Bell, Gloucester City, N. J., assignor to the Welsbach Incandescent Gas Light Co. of N. J. Filed May 10, 1888.

400,167. **Incandescent Gas Lamp.** Harold J. Bell, Gloucester City, N. J., assignor to the Welsbach Incandescent Gas Light Co. of N. J. Filed May 10, 1888.

400,168. **Atmospheric Gas Burner.** Harold J. Bell, Gloucester City, N. J., assignor to the Welsbach Incandescent Gas Light Co. of N. J. Filed May 10, 1888.

400,169. **Incandescent Gas Burner.** Harold J. Bell, Gloucester City, N. J., assignor to the Welsbach Incandescent Gas Light Co. of N. J. Filed June 21, 1888.

400,170. **Gas Governor.** Harold J. Bell, Gloucester City, N. J., assignor to the Welsbach Incandescent Gas Light Co. of N. J. Filed July 2, 1888.

400,171. **Gas Governor.** Harold J. Bell, Gloucester City, N. J., assignor to the Welsbach Incandescent Gas Light Co. of N. J. Filed July 2, 1888.

400,172. **Gas Governor.** Harold J. Bell, Gloucester City, N. J., assignor to the Welsbach Incandescent Gas Light Co. of N. J. Filed July 2, 1888.

400,173. **Gas Governor.** Harold J. Bell, Gloucester City, N. J., assignor to the Welsbach Incandescent Gas Light Co. of N. J. Filed July 2, 1888.

400,174. **Air Regulating Device for Atmospheric Gas Burners.** Harold J. Bell, Gloucester City, N. J., assignor to the Welsbach Incandescent Gas Light Co. of N. J. Filed July 31, 1888.

400,175. **Gas and Air Mixer.** Harold J. Bell, Gloucester City, N. J., assignor to the Welsbach Incandescent Gas Light Co. of N. J. Filed Sept. 6, 1888.

400,176. **Gas and Air Mixer.** Harold J. Bell, Gloucester City, N. J., assignor to the Welsbach Incandescent Gas Light Co. of N. J. Filed Sept. 6, 1888.

400,177. **Gas and Air Mixer.** Harold J. Bell, Gloucester City, N. J., assignor to the Welsbach Incandescent Gas Light Co. of N. J. Filed Sept. 8, 1888.

400,267. **Gas Pressure Injector.** Alfred Thomas, West Cowes, Isle of Wight, and Philip Thomas, Buckingham, County of Bucks, England. Filed July 11, 1888.

400,339. **Automatic Gas Shut-off for Burners.** C. H. Barnett, New York, N. Y. Filed Nov. 16, 1888.

400,363. **Gas Regulator,** J. H. Russ, Providence, R. I. Filed May 26, 1888.

April 2.

400,287. **Gas Furnace.** R. Cartwright, Rochester, N. Y., assignor of one-half to Wm. A. Sweet, Syracuse, N. Y. Filed July 28, 1888.

400,458. Gas Engine. A. Histon, Yonkers, N. Y., assignor of one-half to Otis Bros. & Co., New York, N. Y. Filed April 20, 1888.

400,479. Electric Gas Lighter. J. Y. Parke, Philadelphia, Pa. Filed June 15, 1888.

400,492. Electric Gas Lighting Device. D. Rousseau, New York, N. Y. Filed July 6, 1888.

400,532. Service Pipe Connection for Gas Machines. George Westinghouse, Jr., Pittsburg, Pa. Filed Sept. 13, 1888.

400,683. Forming Gas Outlets. W. M. Jackson, New York, N. Y. Filed Nov. 6, 1888.

April 9.

401,048. Gas Pressure Regulator. W. H. Metcalf, New Haven, Conn. Filed April 27, 1888.

401,153. Electric Gas Lighting Burner. J. Geary, Philadelphia, Pa., assignor to J. Elliott Shaw, same place. Filed Feb. 5, 1889.

401,184. Apparatus for Lighting Gas Burners. A. A. Lister, Camberwell, County of Surrey, England. Filed Jan. 12, 1888.

April 16.

401,342. Apparatus for the Manufacture of Gas. C. M. Gearing, Pittsburg, Pa., assignor to Thomas Liggett, Charles N. Clarke, Robert S. Frazer, and Alex. M. Neeper, all of same place. Filed Sept. 25, 1888.

401,445. Gas Burner for Heating Purposes. P. Lesser, Ridgway, Pa. Filed August 7, 1888.

401,452. Fuel Mixing Device for Gas Engines. L. H. Nash, South Norwalk, Conn., assignor to the National Meter Co. of New York, N. Y. Filed June 22, 1888.

401,453. Gas Engine. L. H. Nash, South Norwalk, Conn., assignor to the National Meter Co. of New York, N. Y. Filed June 22, 1888.

401,570. Apparatus for the Manufacture of Gas. Thaddeus S. C. Lowe, Norristown, Pa., assignor to the Guarantee Trust & Safe Deposit Co. of Pennsylvania, trustees. Filed Nov. 12, 1884.

400,626. Gas Governor. Harold J. Bell, Gloucester City, N. J., assignor to the Welsbach Incandescent Gas Light Co. of N. J. Filed July 2, 1888.

400,627. Gas Governor. Harold J. Bell, Gloucester City, N. J., assignor to the Welsbach Incandescent Gas Light Co. of N. J. Filed Jan. 16, 1889.

401,628. Gas Governor. Harold J. Bell, Gloucester City, N. J., assignor to the Welsbach Incandescent Gas Light Co. of N. J. Filed Jan. 16, 1889.

April 23.

401,898. Process of Making Gas Incandescents. L. Paget, New York, N. Y., assignor of one half to Chas. J. Kintner, same place. Filed March 30, 1889.

401,299. Gas Incandescent. L. Paget, New York, N. Y., assignor of one half to Chas. J. Kintner, same place. Filed March 30, 1889.

April 30.

402,146. Manufacturing Gas. W. M. Cosh, Baltimore, Md. Filed Oct. 19, 1888.

402,177. Gas Burner for Stoves or Fire Places. J. McSweeney, Allegheny, Pa. Filed Aug. 24, 1888.

402,332. Electric Gas Lighter. D. C. Knowlton, Boston, Mass. Filed Oct. 16, 1888.

402,363. Gas Engine. H. Tenting, Paris, France. Filed Jan. 16, 1889.

402,395. Apparatus for the Manufacture of Gas. G. H. Brown, St. Louis, Mo. Filed Jan. 16, 1889.

402,442. Gas Governor. C. J. Hamilton, Philadelphia, Pa., assignor to James H. Wilson, same place. Filed Dec. 15, 1888.

402,534. Gas Generator. S. McIlwaine, Oakwood, Ontario, Can., assignor to Catharine McIlwaine, Toronto, Canada. Filed Feb. 14, 1888.

May 7.

402,655. Gas Burner for Grates and Stoves. J. A. Dailey, Toledo, Ohio. Filed May 28, 1888.

402,749. Gas Engine. S. Lawson, New York, N. Y., assignor to himself and Alonzo T. Welch, same place. Filed Aug. 4, 1888.

402,750. Gas Engine. S. Lawson, New York, N. Y., assignor to himself and Alonzo T. Welch, same place. Filed Aug. 4, 1888.

402,751. Gas Engine. S. Lawson, New York, N. Y., assignor to himself and Alonzo T. Welch, same place. Filed Aug. 4, 1888.

402,787. Purifying Gas. W. A. M. Valon, Ramsgate, assignor of one half to the Continental Oxygen Co., Limited, Westminster, London, England. Filed Sept. 10, 1888.

402,995. **Water Gas Burner.** W. F. Steele, Steele, Dakota. Filed April 8, 1889.

May 14.

403,283. **Apparatus for the Production of Gas.** R. Naysmith, Pittsburg, Pa., assignor of one half to Arthur J. Wilkinson, same place. Filed Aug. 4, 1888.

403,294. **Arc and Gas Engine.** A. Schmid and J. C. Beckfeld, Allegheny, Pa, Filed May 17, 1888.

403,297. **Gas Meter.** W. Y. Stansbrough, Brooklyn, N. Y. Filed Jan. 8, 1889.

403,367. **Gas or Gasoline Engine.** L. C. Parker and B. Parker, Kansas City, Mo. Filed Jan. 11, 1889.

403,769. **Dynamo Speeder for Gas Engine.** N. Rogers and J. A. Wharry, Terre Haute, Ind. Filed Aug. 22, 1888.

403,377. **Carburetor for Gas Engines.** N. Rogers and J. A. Wharry, Terre Haute, Ind. Filed Aug. 22, 1888.

403,378. **Governor for Gas Engines.** N. Rogers and J. A. Wharry, Terre Haute, Ind. Filed Aug. 22, 1888.

403,379. **Gas Engine.** N. Rogers and J. A. Wharry, Terre Haute, Ind. Filed Aug. 22, 1888.

403,380. **Ignitor for Gas Engines.** N. Rogers and J. A. Wharry, Terre Haute, Ind. Filed Aug. 22, 1888.

403,381. **Process of Manufacturing Gas.** J. M. Rose, Allegheny, Pa., assignor by mesne assignments to the National Heat & Power Co. of N. J. Filed Feb. 23, 1888.

403,382. **Process of Manufacturing Gas.** J. M. Rose, Allegheny, Pa., assignor by mesne assignments to the National Heat & Power Co. of N. J. Filed Feb. 23, 1888.

403,383. **Process of Manufacturing Gas.** J. M. Rose, Allegheny, Pa., assignor by mesne assignments to the National Heat & Power Co. of N. J. Filed Feb. 23, 1888.

403,384. **Apparatus for the Manufacture of Gas.** J. M. Rose, Allegheny, Pa., assignor by mesne assignments to the National Heat & Power Co. of N. J. Filed March 27, 1888.

May 21.

403,612. **Gas Burner and Heater.** D. S. Robilliard and C. G. Davies, Quebec, Quebec, Canada. Filed July 31, 1888.

403,803. **Gas Incandescent.** Carl Auer von Welsbach, Vienna, Austria-Hungary, assignor to the Welsbach Incandescent Gas Light Co. of N. J. Filed March 31, 1888.

403,804. **Gas Incandescent.** Carl Auer von Welsbach, Vienna, Austria-Hungary, assignor to the Welsbach Incandescent Gas Light Co. of N. J. Filed March 31, 1888.

May 28.

403,920. **Apparatus for the Manufacture of Gas.** G. K. Cummings, Philadelphia, Pa., assignor by mesne assignments to the United States Gas & Fuel Co. Filed May 22, 1888.

403,921. **Process of Manufacturing Gas.** G. K. Cummings, Philadelphia, Pa., assignor by mesne assignments to United States Gas & Fuel Co. Filed May 22, 1888.

403,994. **Electric Gas Lighter.** J. H. Lehman, Philadelphia, Pa. Filed Aug. 13, 1888.

404,052. **Gas Stove.** William H. Pike, London, England. Filed Nov. 9, 1888.

404,206. **Process of and Apparatus for Manufacturing Gas.**. Burdett Loomis, Hartford, Conn. Filed May 18, 1887.

404,207. **Process of and Apparatus for Manufacturing Gas.** Burdett Loomis, Hartford, Conn. Filed May 24, 1887.

404,208. **Apparatus for the Manufacture of Gas.** Burdett Loomis, Hartford, Conn. Filed April 25, 1888.

404,209. **Manufacturing Gas.** Burdett Loomis, Hartford, Conn. Filed Feb. 23, 1889.

404,322. **Apparatus for Producing Gas.** R. R. Turner, Columbus, O. Filed Aug. 10, 1888.

404,205. **Process of and Apparatus for Manufacturing Gas.** Burdett Loomis, Hartford, Conn. Filed Feb. 18, 1887.

June 4.

404,404. **Apparatus for the Manufacture of Fuel and Illuminating Gas.** J. W. Harrison and Frederic Egner, St. Louis, Mo. Filed Jan. 16, 1889.

404,520. **Apparatus for Manufacturing Gas.** Walton Clark, Philadelphia, Pa., assignor to the United Gas Improvement Co., same place. Filed Oct. 26, 1888.

404,606. **Gas Washer.** Joseph DeBrouwer, Bruges, Belgium. Filed Nov. 13, 1888.

404,733. **Device for Automatically Operating the Stop Cock of a Gas Burner.** C. M. Rider, Newark, O., assignor of one half to Wm. M. Baker, same place. Filed June 6, 1888.

404,750. **Apparatus for the Manufacture of Gas.** Jose F. Toraya, Havana, Cuba, assignor to the Toraya Patent Gas Co., Philadelphia, Pa. Filed Jan. 17, 1889.

June 11.

404,830. **Gas Burner.** Wm. F. Folmer, New York, N. Y., assignor of one half to Walter E. Schwing, same place. Filed Aug. 1, 1888.

404,886. Gas Generating Apparatus. W. G. Bedford, Philadelphia, Pa. Filed April 17, 1888.

405,051. Gas Furnace. E. P. Reichelm, Jersey City, N. J. Filed Dec. 8, 1888.

405,126. Automatic Gas Lighting and Extinguishing Apparatus. N. H. Shaw, Somerville, Mass., assignor to the American Automatic Gas Lighting Co., Portland, Me. Filed May 14, 1888.

405,139. Heating Gas Burner. S. L. Wiegand, Philadelphia, Pa. Jan. 6, 1888.

June 18.

405,435. Automatic Gas Lighting and Extinguishing Apparatus. N. H. Shaw, Somerville, Mass., and A. B. Shaw, Medford, Mass. Said N. H. Shaw, assignor to J. Elliott Shaw, same place. Filed Feb. 5, 1889.

405,656. Gas Regulating Burner. O. W. Bennett, Washington, D. C. Filed Oct. 18, 1888.

June 25.

405,701. Gas Holder. William Gadd, Manchester, England. Filed August 28, 1888.

405,702. Gas Holder. William Gadd, Manchester, England. Filed Feb 18, 1889.

405,735. Gas Burner. L. Henkle, Rochester, N. J. Filed July 28, 1888.

405,736. Incandescent Gas Burner. L. Henkle, Rochester, N. Y. Filed March 1, 1889.

405,747. Apparatus for Carburetting Air or Gas. D. J. Snyder and L. Stephenson, Scio, O. Filed Jan. 14, 1889.

405,830. Automatic Cut-off and Gas Regulator. C. A. Dally and H. K. Richardson, Pittsburg, Pa. Filed Oct. 8, 1888.

405,911. Gas Generator. W. Rennyson, Norristown, Pa. Filed Jan. 30, 1888.

405,943. Gas Vending Apparatus. R. W. Brownhill, Aston New Town, Birmingham, County of Warwick, England. Filed June 12, 1888.

405,944. Gas Vending Apparatus. R. W. Brownhill, Aston New Town, Birmingham, County of Warwick, England. Filed June 29, 1888.

405,983. Gas Vending Apparatus. R. W. Brownhill, Aston New Town, Birmingham, County of Warwick, England. Filed June 12, 1888.

July 2.

406,124. **Apparatus for Washing and Scrubbing Gas.** Samuel Chandler, Samuel Chandler, Jr., and Josia Chandler, London, England, assignors to Kirkham, Hulett & Chandler, Limited, same place. Filed Feb. 6, 1889.

406,160. **Gas Motor.** C. T. A. H. Wiedling, New York, N. Y., assignor to John S. Connelly, Plainfield, N. J., and Thomas E. Connelly, Brooklyn, N. Y. Filed Dec. 22, 1887.

406,241. **Gas Leak Detector.** J. F. Stark, New Haven, Conn. Filed March 27, 1889.

406,229. **Gas Burner for Stoves or Fire Places.** T. McSweeney, Allegheny, Pa. Filed Feb. 11, 1889.

406,263. **Gas Engine.** L. T. Connell, Chicago, Ill., assignor to the Cornell Engine Co., same place. Filed Oct. 13, 1888.

July 9.

406,637. **Apparatus for the Manufacture of Fuel Gas.** Mary T. Dwight, administratrix of Geo. S. Dwight, deceased. Original application filed Oct. 2, 1884. Divided and this application Jan. 14, 1888.

406,718. **Apparatus for Forcing Gas Through Mains.** J. S. Fish, Choestoe, Ga. Filed Nov. 27, 1888.

406,762. **Igniting Apparatus for Gas or Oil Motor Engines.** N. A. Otto Cologne, assignor to the Gas-Motoren-Fabrik-Deutz, Deutz-on-the-Rhine, Germany. Filed Nov. 6, 1888.

406,807. **Gas Engine.** C. White and A. R. Middleton, Baltimore, Md. Filed Jan. 18, 1889.

406,819. **Apparatus for the Manufacture of Gas.** J. M. Critchlow, Beaver Falls, Pa., assignor of one half to E. T. Roberts, Titusville, Pa., and Hugh McKay, of London, Canada. Filed June 9, 1887.

406,860. **Gas Burner for Stoves or Fire Places.** J. Smithley, Pittsburg, Pa., assignor to the Fuel, Gas & Electric Engineering Co., Limited, same place. Filed March 15, 1889.

July 16.

406,894. **Gas Pressure Guage and Regulator.** C. B. Fearnley, Brixton, County of Surrey, England. Filed July 14, 1887.

407,025. **Apparatus for Scrubbing and Washing Gas.** Kerr M. Mitchell, St. Joseph, Mo. Filed June 22, 1888.

407,134. **Heating Gas Burner.** S. Stewart, Newark, N. J. Filed August 14, 1888.

407,237. **Gas Mixer.** W. S. Payne, Fostoria, O. Filed April 12, 1888.

407,267. **Apparatus for Generating Gas from Petroleum Oil.** A. Weyer, Talapoosa, Ga. Filed Jan. 12, 1889.

407,289. **Gas Furnace.** R. S. Franz, Glenshaw, Pa. Filed May 31, 1888.

407,291. **Gus Burner.** C. J. Hamilton, Philadelphia, Pa., assignor to James H. Wilson, same place. Filed July 28, 1888.

July 23.

407,320. **Gas Engine.** C. W. Baldwin, Yonkers, N. Y., assignor to William E. Hale, Chicago. Ill. Filed July 23, 1888.

407,321. **Gas Engine.** C. W. Baldwin, Yonkers, N. Y., assignor to William E. Hale, Chicago, Ill. Filed Oct. 9, 1888.

407,323. **Gas Burning Device.** J. F. Barker, Springfield, Mass. Filed August 13, 1886.

407,622. **Inverted Gas Lamp.** D. W. Sugg, Westminster, England. Filed Jan. 28, 1886.

407,645. **Gas Governor or Regulator.** W. H. Downing, Goodell, Pa. Filed March 15, 1889.

407,656. **Regulating Gas Burner.** J. G. Hawkins and J. Barton, Peterborough, County of Northampton, England. Filed Feb. 27, 1889.

July 30.

407,933. **Gas Stove.** L. Ketchum, Saugatuck, Conn. Filed April 10, 1888.

407,936. **Gas Washing Apparatus.** E. Ledig, Shemnitz, Saxony, Germany, assignor of one half to Bruno Terne, Philadelphia, Pa. Filed Aug 27, 1888.

408,068. **Incandescent Gas Lamp.** Harold J. Bell, Woodbury, N. J., assignor to the Welsbach Incandescent Gas Light Co. of N, J. Filed March 8, 1888.

408,069. **Incandescent Gas Lamp.** Harold J. Bell, Gloucester City, N. J., assignor to the Welsbach Incandescent Gas Light Co. of N. J. Filed Sept. 6, 1888.

408,071. **Gas Governor.** Harold J. Bell, Gloucester City, N. J., assignor to the Welsbach Incandescent Gas Light Co. of N. J. Filed Jan. 16, 1889.

408,072. **Incandescent Gas Lamp.** Harold J. Bell, Woodbury, N. J., assignor to the Welsbach Incandescent Gas Light Co. of N. J. Filed March 21, 1888.

407,961. **Combined Gas Engine and Carburetor.** L. F. McNett, Yonkers, N. Y., assignor to the American Motor Co., New York, N. Y. Filed Sept. 15, 1887.

408,051. Incandescent Gas Burner. John L. Stewart, Philadelphia, Pa., assignor by mesne assignments to the Welsbach Incandescent Gas Light Co., Gloucester, N. J. Filed Dec. 27, 1887.

408,137. Gas Motor Engine. J. J. Purnell, Lambeth, County of Surrey, England. Filed May 15, 1889.

August 6

408,356. Gas Engine. D. S. Regan, San Francisco, Cal. Filed April 5, 1888.

408,532. Process of Manufacturing Gas.. J. M. Rose, Allegheny, Pa. Filed May 9, 1888.

408,533. Apparatus for the Manufacture of Gas. J. M. Rose, Allegheny, Pa. Filed May 9, 1888.

408,534. Process of Manufacturing Gas. J. M. Rose, Allegheny, Pa. Filed Oct. 4, 1888.

408,535. Manufacture of Gas. J. M. Rose, Allegheny, Pa. Filed Oct. 16, 1888.

408,536. Apparatus for the Manufacture of Gas. J. M. Rose, Allegheny, Pa. Filed Dec. 8, 1888.

408,674. Apparatus for the Manufacture of Gas. J. M. Rose, Allegheny, Pa. Filed Oct. 4, 1888.

August 13.

408,683. Gas Engine. C. W. Baldwin, Yonkers, N. Y., assignor to William E. Hale, Chicago, Ill. Filed March 1, 1888.

408,785. Electric Gas Lighter. T. J. Zoeller, Louisville, Ky., assignor to himself, D. E. Doherty, B. D. Mattingly and C. J. Doherty, same place. Filed Dec. 10, 1888.

408,873. Gas Pressure Regulator. C. W. Crozier, Muncie, Ind. Filed March 27, 1889.

408,980. Gas Heater. J. Johnson and E. H. Packer, Lowell, Mass. Filed Jan. 28, 1889.

409,090. Gas Furnace. J. Zellweger, Chicago, Ill. Filed Dec. 19, 1887.

August 20,

409,275. Gas Meter. J. W. Culmer, New Brighton, Pa., assignor to John J. Logan, same place. Filed March 28, 1889.

409,375. Gas Pressure Injector. R. L. Simons, Lima, O. Filed Sept. 27, 1888.

409,498. Combined Gas and Electric Fixture. T. J. Pierce, Philadelphia, Pa. Filed June 19, 1888.

409,520. Incandescent Gas Burner. John L. Stewart, Philadelphia, Pa., assignor by mesne assignments to the Welsbach Incandescent Gas Light Co. of N. J. Filed Dec. 16, 1887.

409,528. **Gas Incandescent.** Carl A. von Welsbach, Vienna, assignor to the Welsbach Incandescent Gas Light Co. of N. J. Filed March 31, 1888.

409,531. **Manufacture of Gas Incandescents.** Carl A. von Welsbach, Vienna, Austria-Hungary, assignor to the Welsbach Incandescent Gas Light Co. of N. J. Filed March 31, 1888.

409,607. **Method of making incandescing Elements for Gas Burners.** C. B. Harris, New York, N. Y. Filed April 24, 1889.

409,530. **Incandescent Gas Lamp.** Carl A. von Welsbach, Vienna, Austria-Hungary, assignor to the Welsbach Incandescent Gas Light Co. of N. J. Filed March 31, 1888.

409,554. **Incandescent Gas Lamp.** Harold J. Bell, Woodbury, N. J., assignor to the Welsbach Incandescent Gas Light Co. of N. J. Filed March 31, 1888.

409,626. **Gas Pressure Regulator.** Harold J. Bell, Gloucester City, N. J., assignor to the Welsbach Incandescent Gas Light Co. of N. J. Filed June 6, 1889.

409,627. **Gas Pressure Regulator.** Harold J. Bell, Gloucester City, N. J., assignor to the Welsbach Incandescent Gas Light Co. of N. J. Filed June 6, 1889.

August 27.

409,719. **Gas and Air Mixing Machine.** L. B. White, New York, N. Y. Filed June 28, 1888.

409,727. **Gas Lighter.** S. B. Battey, New York, N. Y. Filed July 31, 1888.

409,761. **Apparatus for the Manufacture of Gas.** W. T. Stewart, Pittsburg, Pa., assignor of three fourths to Wm. H. Denniston, same place. Filed Jan. 18, 1889.

409,763. **Gas Stove.** W. Swindell, Allegheny, Pa. Filed March 19, 1888.

410,001. **Automatic Safety Lock for Gas.** A. H. McClure and H. Holland, McGovern, Pa. Filed May 3, 1889.

410,092. **Gas Stove Burner.** H. R. Gummer, Dayton, O. Filed Feb. 20, 1889.

September 3.

410,174. **Apparatus for the Manufacture of Gas.** Frank D. Moses, Zanesville, O. Filed May 15, 1889.

410,286. **Apparatus for Manufacturing Non-luminous Heating Gas.** A. Kitson, Philadelphia, Pa. Filed Dec. 8, 1888.

410,418. **Gas and Air Mixer and Governor.** C. F. Hovey, Springfield, Mass. Filed March 19, 1888.

410,540. **Incandescent Gas Burner.** E. C. Davidson, New York, N. Y. Filed April 1, 1889.

410,549. **Incandescent Gas Burner.** Chas. B. Harris, New York, N. Y. Filed April 29, 1889.

410,566. **Gas Burner for Lighting, Cooking and Heating Purposes.** J. H. Keyser, New York, N. Y. Filed April 13, 1889.

September 10.

410,792. **Gas Stove.** J. Gibbons, Jersey City, N. J. Filed March 30, 1887.

410,820. **Apparatus for Manufacturing Gas.** H. S. Battin, Chicago, Ill. Filed April 2, 1889.

410,846. **Cupola Gas Generating Furnace.** M. A. Morse, Chicago, Ill. Filed April 2, 1889.

410,944. **Gas Generator and Burner.** J. G. Street, Dallas, Texas. Filed April 11, 1889.

September 17.

411,022. **Apparatus for the Manufacture of Gas.** V. L. Elbert, Minneapolis, Minn. Filed Jan. 28, 1889.

411,062. **Gas Regulator.** William C. Rossney, Hyde Park, assigner of two-thirds to Wm. Threlkeld and Charles L. Hunt, Boston, Mass. Filed Oct. 2, 1888.

411,063. **Gas Regulator.** William C. Rossney, Hyde Park, assignor of two-thirds to Wm. Threlkeld and Charles L. Hunt, Boston, Mass. Filed Oct. 2, 1888.

411,389. **Process of and Apparatus for Manufacturing Gas.** M. A. Morse, Chicago, Ill., and T. G. Springer, New York, N. Y. Filed Aug. 20, 1887.

September 24.

411,126. **Heating Attachment for Gas Burners.** Charles Long, Toronto, Ontario, Canada. Filed Sept. 30, 1888.

411,447. **Gas Heater.** J. Johnson and E. H. Packer, Lowell Mass. Filed May 10, 1889.

411,478. **Solvent for Gas Pipe Deposits.** M. E. Waldstein, New York, N. Y. Filed Nov. 22, 1888.

411,566. **Automatic Cock or Cut-off for Gas Burners.** C. H. Barnett, New York, N. Y. Filed Nov. 16, 1888.

411,648. **Multiple Heating Gas Burner.** A. J. Doty, Philadelphia, Pa., assignor by mesne assignments to the Goodwin Gas Stove & Meter Co., same place. Filed June 6, 1887.

411,649. **Gas Stove.** A. J. Doty, Philadelphia, Pa., assignor by mesne assignments to the Goodwin Gas Stove & Meter Co., same place. Filed June 6, 1887.

411,668. **Gas Engine.** J. Matthies, Berlin, Germany. Filed Nov. 14, 1888.

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G. W., XLIII-1110-756
The Analysis of Raw and Spent Lime, H. L. Greville.
Simple Methods of Gas Analysis, S. J. B. Tully, G. W., XLV-1153-357

DISTRIBUTION.

INCLUDING EVERYTHING PERTAINING TO THE HANDLING OF THE GAS FROM THE HOLDER TO THE CONSUMER'S OUTLET.

Gas Pressure in Manhattan Borough, A. G. L. J., LXXXIII-14-536
Improvements to date in Consumer's Meters,
A. G. L. J., LXXXIII-19-751
P. A., XXIII-22-620
High Pressure Gas Distribution of To-day, H. L. Rice,
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